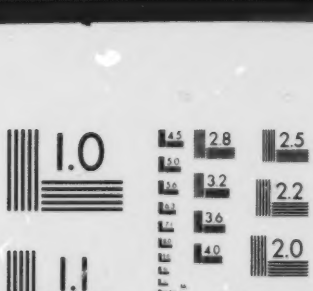

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ABSTRACT

The School Retrofit Design Analysis System (SRDAS) developed in this study provides a non-technical method for the school administrator to use in evaluating alternative energy saving retrofit and new construction design possibilities. By providing a high degree of flexibility, SRDAS is applicable to a wide range of school building and retrofit situations. SRDAS is a microcomputer model utilizing the Apple II microcomputer and "basic" language programming, which allows the school administrator to develop feasibility studies on various energy conservation scenarios. The ability to perform calculations needed for the administrator's credibility in discussions of possible energy plans is enhanced by using SRDAS. The ability to challenge energy vendor claims and to deal knowledgeably with engineers and architects is a feature the analysis system provides to the school manager. Several surveys and interviews are described which delineate the necessary features of an analysis system. The legal aspects, including statutes, regulations, and executive orders affecting school energy consumption and saving are described. A sample run is made using the SRDAS and the effects on the analysis of each of the subprograms are described. A complete listing of the various subprograms making up the SRDAS is provided along with the flow diagrams showing the program logic.
(Author/JN)

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School Retrofit Design Analysis System

a microcomputer model for school energy use

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ABSTRACT

The School Retrofit Design Analysis System (SRDAS) developed in this study provides a non-technical method for the school administrator to use in evaluating alternative energy saving retrofit and new construction design possibilities. SRDAS is a tool which is readily available to the school manager. By providing a high degree of flexibility, SRDAS is applicable to a wide range of school building and retrofit situations.

Using SRDAS, the school administrator can provide informed guidance both within the organization and with dealings outside the school community. SRDAS is a microcomputer model utilizing the Apple II microcomputer and "basic" language programming, which allows the school manager to develop feasibility studies on various energy conservation scenarios. The ability to perform the wide number of calculations needed for the administrator's credibility in discussions of possible energy plans is enhanced through the use of SRDAS. The ability to challenge energy vendor claims and to deal knowledgeably with engineers and architects is a feature the analysis system provides to the school manager.

A number of surveys and interviews are described which delineate the necessary features of an analysis system. The legal aspects, including statutes, regulations, and executive orders affecting school energy consumption and savings are described.

A sample run is made using the SRDAS and the effects on the analysis of each of the subprograms are described. A complete listing of the various subprograms making up the SRDAS is provided along with the flow diagrams showing the program logic.

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DEDICATION

To Sharon, Marty, Avinelle, Johnny, and Mom and Dad without whose help and encouragement this study could not have been completed.

TABLE OF CONTENTS

ABSTRACT iii

ACKNOWLEDGMENTS iv

DEDICATION v

LIST OF ILLUSTRATIONS vii

Chapter

I. INTRODUCTION 1

II. REVIEW OF THE LITERATURE 9

III. GOVERNMENTAL ACTIVITIES IMPACTING SCHOOL ENERGY USE 20

IV. USE OF PROGRAM 58

V. SUMMARY AND CONCLUSIONS 91

APPENDICES

Appendix A: Sample Run for Newell Elementary School - 1958 Building 95

Appendix B: Program Listings 133

SOURCES CONSULTED 165

LIST OF ILLUSTRATIONS

1. Federal Energy Administration Regions Listed by State..... 10

2. Comparison of Per Capita Pupil Energy Consumption (1972-73) to (1974-75)..... 11

3. Comparison of Percent of New School Construction Using Various Heat Sources, 1975 and 1980..... 11

4. Btu Equivalents for Various Energy Types..... 12

5. Per Pupil Dollar Costs of Heat and Other Utilities in the Nation's Schools..... 13

6. Comparison of Savings vs. Costs in Insulation..... 18

7. Typical Design Considerations in North Carolina Schools (1950-70)..... 19

8. Energy Audit Data from North Carolina Public Schools (K-12) in 1979..... 33

9. Prescriptive Criteria for Buildings in North Carolina..... 44

10. N. C. Counties Listed by Their Thermal Zone Locations..... 45

11. Six Month Billing History for Newell Elementary School (1981-82)... 54

12. Title Screen Shown When Program Is Loaded into Computer Memory..... 61

13. Introductory Screen for SRDAS..... 61

14. Primary Menu from School Retrofit Design Analysis System..... 62

15. Introductory Screen for Building Analysis Subprogram..... 62

16. Menu Screen from Building Analysis Subprogram..... 63

17. Introductory Screen from Btu/Sq. Ft. Subprogram..... 64

18. Menu Screen from Btu/Sq. Ft. Subprogram..... 65

19. Introductory Screen from Roof Subprogram..... 65

20. Information Screen from Roof Subprogram..... 66

21. Information Gathering Screen from Roof Subprogram..... 66

22. Summary Screen for Roof Subprogram..... 67
23. Introductory Screen from Floor Subprogram..... 68
24. Information Gathering Screen from Floor Subprogram..... 68
25. Informational Screen from Floor Subprogram..... 68
26. Summary Screen from Floor Subprogram..... 69
27. Introductory Screen from Infiltration Subprogram..... 69
28. Information Gathering Screen from Infiltration Subprogram..... 70
29. Information Gathering Screen from Infiltration Subprogram..... 70
30. Information Screen from Infiltration Subprogram..... 71
31. Summary Screen from Infiltration Subprogram..... 71
32. Informational Gathering Screen from Infiltration Subprogram..... 71
33. Introductory Screen from Wall Subprogram..... 72
34. Basic Wall Calculation Screen from Wall Subprogram..... 72
35. Informational Screen from Wall Subprogram..... 73
36. Informational Screen from Wall Subprogram..... 73
37. Introductory Screen in Window Subprogram..... 74
38. Informational Gathering Screen from Window Subprogram..... 75
39. Informational Screen from Window Subprogram..... 75
40. Informational Screen from Window Subprogram..... 76
41 Informational Screen in Window Subprogram..... 76
42. Summary Screen for Window Subprogram..... 77
43. Screen Showing Percent Instructional Use Space..... 78
44. Introductory Screen for Total Daily Student Cost Subprogram..... 79
45. Screen Gathering Information for Total Daily Student Cost Subprogram..... 80
46. Informational Gathering Screen for Total Daily Student Cost Subprogram..... 80
47. Informational Gathering Screen for Total Daily Student Cost Subprogram..... 80

48. Summary Screen for Total Daily Student Cost Subprogram..... 81
49. Informational Screen for Energy Costs Subprogram..... 82
50. Summary Screen for Energy Costs Subprogram..... 82
51. Introductory Screen for Btu/Sq. Ft. Subprogram..... 83
52. Informational Gathering Screen for Btu/Sq. Ft. Subprogram..... 84
53. Summary Screen for Btu/Sq. Ft. Subprogram..... 84
54. Introductory Screen for Payback Subprogram..... 85
55. Information Gathering Screen for Payback..... 86
56. Information Presenting Screen for Payback..... 86
57. Summary Screen for Payback..... 87
58. Flow Chart of SRDAS Subprograms..... 134
59. Building Analysis Flow Chart..... 138
60. Roof Subprogram Flow Chart..... 139
61. Floor Subprogram Flow Chart..... 140
62. Infiltration Subprogram Flow Chart..... 141
63. Walls Subprogram Flow Chart..... 142
64. Window Subprogram Flow Chart..... 143
65. End Subprogram Flow Chart..... 144
66. Btu/Sq. Ft. Subprogram Flow Chart..... 165
67. Percent Instructional Use Space Flow Chart..... 166
68. Total Daily Student Costs Subprogram Flow Chart..... 167
69. Energy Costs (Electric) Subprogram Flow Chart..... 168
70. Btu/Sq. Ft. Subprogram Flow Chart..... 169
71. End Subprogram Flow Chart..... 170
72. Payback Flow Chart..... 180
73. End Subprogram Flow Chart..... 187
74. Figure Showing Variables Used in SRDAS..... 190

A MICROCOMPUTER MODEL FOR SCHOOL ENERGY USE

CHAPTER I

INTRODUCTION

Background

Approximately twenty-five percent of the nation's population attend school. Schools may account for eleven percent of the nation's entire space conditioning budget. With energy costs increasing it is important for school managers to be aware that for each percent increase in school energy costs, the national school budget must be increased by about five million dollars.[1] Local administrators must deal with increased costs but on a smaller scale as related to their system.

The ultimate result of energy cost increases in providing a healthy and safe environment at school will probably impact the school program and teacher salaries.[2] Cuts in program and salary areas are likely since these two areas may be perceived as less essential than transportation and space conditioning.

Educational administrators have not been complacent while energy costs eroded their budgets. Some administrators attempted to limit the effects school energy cost increases have had on the school budgets. What the efforts of these administrators showed was that there were many variables affecting school energy use. A number of studies have been instituted to

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[1]Calvin E. Anderson, "The Impact of the Energy Crisis on School Finance," Phi Delta Kappan 57 (November 1975): 193.

[2]Ibid., p. 194.

explore variables such as energy cost elasticity, fuel types, and the impact of maintenance and operations on costs.[1,2,3]

A number of laws and regulations have been enacted since the Arab oil embargo. The North Carolina legislature has enacted few school laws which deal directly with energy issues; however, some laws have potential for impact on energy use even though energy was not the primary focus.[4] Regulations promulgated by the North Carolina State Board of Education have had a greater impact than the specific statutes.

Regulations mandating such things as temperature settings for space conditioning and water heating, energy sources used in heating system conversions, community use of facilities, and electrical load management have been adopted.[5]

Federal laws have also had an impact on the energy operations of the schools. The federal effort has been generally confined to three major pieces of legislation, the Energy Policy and Conservation Act, the Energy Conservation and Production Act, and the National Energy Conservation Policy Act. The laws will be explained in chapter III. Each law affected the

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[1]American Association of School Adminstrators, AASA Energy Use Study, (Arlington, Va.: AASA Office of Governmental Relations, Aug. 1979).

[2]Ed Stephan, "The Impact of Rising Fuel Costs," American School and University 49 (December 1976): 34-37.

[3]Paul Abramson, "Seventh Annual Maintenance and Operators Cost Study," American School and University 50 (March 1978): 58-66.

[4]North Carolina State Board of Education, Public School Laws of North Carolina, (Charlottesville, Va.: Michie Company, 1979).

[5]"N. C. School Plant Conservation Policy," (Raleigh, N.C.: N. C. Board of Education, 2 August 1979).

schools a little differently but each had as a desired outcome the conservation of energy in the school community.[1,2,3]

Purpose

The purpose of this study was to develop a practical method using a microcomputer for assessing the economics and desirability of various energy conservation measures in new building construction and in the retrofitting of existing buildings. The method is called the School Retrofit Design Analysis System (SRDAS).

With information available through the analysis system, the administrator can make informed decisions about energy vendor claims for a particular school facility. In addition, the ability of administrators to evaluate various energy saving scenarios will be enhanced.

Information obtained from the surveys of the American Association of School Administrators and American School and University magazine form a basis for the analysis. Information extracted from these two surveys examined in chapter II and the legislative and policy actions described in chapter III helped delineate the features found in the analysis.

Justification

The cost and availability of engineering expertise to perform energy analysis for retrofit and new applications varies from company to company.

---

[1]Energy Policy and Conservation Act, U.S. Code, vol. 42, Sec. 6201 (1975).

[2]Energy Conservation and Production Act, U.S. Code, vol. 42, Sec. 6801 (1976).

[3]National Energy Conservation Policy Act, U.S. Code, vol. 42, Sec. 8201 (1978).

A conservative estimate of charges by a respected company for a general energy analysis is approximately five to ten thousand dollars.[1]

The typical absence of engineering firms from the school location except when hired can be a problem. The computer analysis has the advantage of being available immediately to administrators for the analysis of a project. The subprograms which form the analysis are designed to be easily used and understood by those people who are computer novices. Once the analysis system has been properly entered into the computer, the user has only to respond to questions to be successful in using the system.

Procedure

Through the use of a series of computer programs, the school administrator will be able to make informed energy decisions about retrofit and new construction options. Developmental work on these programs was done on the Apple II microcomputer manufactured by Apple Computer in Cupertino, California. The program listing is included in the appendix so that the program can be entered into any computer. The computer language used is designed for unmodified cross-use on any computer using the language called "basic."

While operational characteristics can have a large impact on the school energy budget, the research presented in this study focused on non-operational aspects such as adding insulation, improving window glazing, and reducing infiltration. Since no particular energy type was emphasized, all energy data are presented in a common unit -- the British thermal unit (Btu). This standardization allows cost comparisons among the various energy sources.

---

[1]Interview with Robert E. Bryan, P. E., N. C. Dept. of Public Instruction, Raleigh, North Carolina, 22 April 1981.

The computer analysis enables an administrator to enter proposed energy-saving characteristics of new construction into the computer and to determine the life cycle costs. The same procedure works for planned modifications of existing buildings.

Use of part one of the analysis enables the administrator to examine Btu use per square foot, to calculate the percent of space devoted to instruction and the daily student costs, and to validate the electricity charges. Part two allows the user to assess the value of energy modifications to the roof, floor, walls, windows, and infiltration sites. A final section allows for the determination of payback periods for the projected savings determined in the second part of the analysis.

Chapter II presents an historical perspective on school energy use. Cost trends in school energy expenditures are described and a rationale for administrative action is presented.

Chapter III contains the laws, rules, and regulations which deal with North Carolina school energy use. Only laws which have a potential for impact on school buildings are included.

An explanation of the computer analysis is the subject of Chapter IV. The explanation was designed to minimize computer jargon. The chapter is a step-by-step guide to the program.

Chapter V is the summary and conclusion. There are two appendices which present the program listing, program variables, and a sample run using Newell Elementary School in Charlotte, North Carolina.

Model Development

Schools present a situation that is perhaps unique in the design trade. Schools built during the same period are practically identical. Three categories of schools have been identified. The schools built prior to 1950

made up one of the categories. These facilities represented about twenty-seven percent of the classrooms in North Carolina in 1981. The North Carolina Building Code does not allow most of these structures to be renovated due to inadequate fire-resistant construction.[1] These schools have not been considered in designing the model.

Schools constructed in the twenty-year period from 1950 to 1969 represent the group which is the focus for the model called School Retrofit and Design Analysis System (SRDAS). These schools housed about fifty-two percent of the children in 1981. These schools have a fire-resistive construction with masonry walls, steel bar joists, and slab-on-grade foundations. Consequently, they have a life expectancy of many years.

Those buildings which were constructed within the 1950 to 1969 period had a distinctive design, and can be characterized as having window walls, a campus-plan with separate buildings, and little or no insulation. Cost estimates for improving these buildings range up to fifty percent of the cost of new construction.[2] Although the investment for improving these buildings can be substantial, significant reductions in cost of energy are possible.

School buildings constructed after 1969 generally were compact in design with substantial insulation, few windows, and few hallways.

In January, 1981, each board of education in North Carolina submitted an estimate of school facility needs. The cost estimate for the state was almost two billion dollars. Of this amount, over five percent was identified as needed for renovations to increase energy efficiency.

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[1]Craig Phillips, "North Carolina Has Many Facility Needs," Presentation to School Board Association, December, 1981. (Mimeographed.)

[2]Ibid.

Over one billion dollars was identified as the costs of needed new construction.[1]

Engineers have several methods to help them in their evaluation of energy improvements and of energy efficient construction. Unfortunately, no simple method existed for the school administrator or school board members prior to the creation of SRDAS to evaluate proposed changes. There were several computer programs on the market which could be used to evaluate types of construction varying from mobile homes to chicken houses.[2] No program designed for the non-engineer to use in making the preliminary evaluation of possible energy saving improvements was available.[3]

The SRDAS was written in a manner that will enable the user to utilize the program no matter when a particular building was constructed. Specific design features were identified through discussion with Duke Power Company engineers and consultants in the North Carolina Department of Public Instruction.[4],[5],[6] While those schools built in 1950-69 form the focus for SRDAS, the program is flexible enough to be utilized for either older construction or for analysis of school buildings not yet begun. This

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[1]North Carolina School Boards Association, "Where Do We Go from Here?" Pamphlet from School Board Association, 1981, p. 1.

[2]Interview with Don Hamby, Duke Power Company, Charlotte, North Carolina, 11 November 1981.

[3]"University Marketing 3 Software Programs," Energy Users News, 2 November 1981, p. 13.

[4]Interview with Ernest Dowless, Duke Power Company, Charlotte, North Carolina, 18 November 1981.

[5]Interview with Robert Bryan, North Carolina Division of Plant Operations, Raleigh, North Carolina, 19 November 1981.

[6]Interview with Darrell Spencer, North Carolina Division of School Planning, Raleigh, North Carolina, 9 December 1981.

flexibility is available to the user through the input to the questions presented on the video screen.

CHAPTER II

REVIEW OF THE LITERATURE

In this chapter the energy studies which have been done in the nation's schools and which identify common areas of concern will be reported. Prior to the Arab oil embargo and the resulting energy consciousness, school energy use and costs were not the focus of research. Most of the research examined in this chapter was conducted after the oil embargo.

The American Association of School Administrators (AASA) and the Federal Energy Administration divided the country into ten regions for purposes of energy analysis. Figure 1 shows the states found in each of the regions.[1]

Following the Arab oil embargo of 1973-74, concern over energy availability grew rapidly. Ed Stephan, one of the researchers doing energy analysis at the time, surveyed schools in the ten national regions. The total sample consisted of 498 school districts. School districts in the sample were classified into six size groups ranging from fewer than one thousand students to those districts with more than twenty-five thousand students.[2]

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[1]American Association of School Administrators, AASA Energy Use Study, (Arlington, Va.: AASA Office of Governmental Relations, August 1979), p. 5.

[2]Ed Stephan, "The Impact of Rising Fuel Costs, "American School and University 49 (December 1976): 34.

The per capita student energy consumption described by Stephan and shown in Figure 2 is demonstrative of a general trend away from oil, propane, and coal to natural gas and electricity.

Region 1	Region 5	Region 9
Maine	Minnesota	California
New Hampshire	Wisconsin	Nevada
Vermont	Michigan	Arizona
Massachusetts	Illinois	Hawaii
Connecticut	Indiana	
Rhode Island	Ohio	
Region 2	**Region 6**	**Region 10**
New York	New Mexico	Washington
New Jersey	Oklahoma	Oregon
	Texas	Idaho
	Arkansas	Alaska
	Louisiana	
Region 3	**Region 7**	
Pennsylvania	Nebraska	
Maryland	Iowa	
Delaware	Kansas	
Virginia	Missouri	
West Virginia		
Region 4	**Region 8**	
Kentucky	Montana	
Tennessee	North Dakota	
North Carolina	South Dakota	
South Carolina	Wyoming	
Georgia	Utah	
Alabama	Colorado	
Mississippi		
Florida		

Fig. 1. Federal Energy Administration regions listed by state[1]

[1]AASA Energy Use Study, p. 5.

Energy Type	1972-73	1974-75	% Change
Fuel Oil (gal.)	37.17	33.33	-10.3
Natural Gas (CCF)	5694.48	5813.01	1.0
Coal (tons)	0.10	0.07	-30.0
Electricity (Kwh)	507.60	558.80	10.0
Propane (gal.)	2.04	1.64	-19.6

Fig. 2. Comparison of per capita pupil energy consumption (1972-73) to (1974-75)[1]

In an on-going survey conducted by the American School and University staff, trends in the source of heating energy for schools became apparent. The results from the survey of 1975 and the survey of 1980 are presented in figure 3.

Type of School	1975				1980			
	Gas	Oil	Electric	Solar	Gas	Oil	Electric	Solar
Elementary	44%	18%	36%	1%	69%	16%	20%	2%
Middle	41%	20%	38%	3%	55%	10%	30%	5%
High	33%	21%	46%	0%	61%	18%	29%	3%

(Numbers add to more than 100% because of multiple energy sources.)

Fig. 3. Comparison of percent of new school construction using various heat sources 1975 and 1980[2],[3]

One of the interesting observations from this comparison of new building heating sources was the decline in the use of electricity as a

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[1]Stephan, "Impact of Rising Fuel Cost," p. 34.

[2]Paul Abramson, "Educational Construction in 1977," American School and University 50 (May 1978): 32.

[3]Paul Abramson, "Educational Construction," American School and University 53 (April 1981): 55.

heating source. With the exception of middle schools, oil has retained its share of new school heat sources without much decrease. Gas heating plants were much more common in buildings constructed in 1980 than those built in 1975.

While school managers are, and should be, concerned with energy consumption, another factor may enter heavily into administrative decisions. This factor is the cost of energy. Cost comparison figures are hard to interpret unless there is some common conversion unit applied to gallons, kilowatt-hours, cubic feet, and tons. Stephan suggested the use of the British thermal unit (Btu) as the common unit. His conversion factors are shown in figure 4.

Fuel oil, 1 gallon	=	138,700 Btu
Natural gas, 1 cu. ft.	=	1,031 Btu
Electricity, 1 Kwh	=	3,400 Btu
Coal, 1 ton	=	24,580,000 Btu
Propane, 1 gallon	=	95,500 Btu

Fig. 4. Btu equivalents for various energy types[1]

Using the Btu conversion method, the AASA study found that the school energy consumption per square foot of floor space in 1979 was 104,445 Btu.[2]

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[1]Stephan, "Impact of Rising Fuel Cost," p. 37.

[2]AASA Energy Use Study, pp. 1-3.

Stephan's energy analysis study conducted in 1975 showed a per square foot Btu consumption in 1972-73 to be 161,312. By 1974-75, consumption per square foot had dropped to 148,113 Btu.[1]

The average energy costs per pupil were compiled for selected years from 1969-81. These costs are shown in figure 5.

	1969	1973	1977	1981
Heat	$ 7.38	$ 7.94	$18.79	$46.00
Other Utilities	$11.07	$16.23	$31.71	$58.00
Total	$18.45	$24.17	$50.50	$104.00

Fig. 5. Per pupil dollar costs of heat and other utilities in the nation's schools[2]

The energy costs over the period from 1969 to 1981 rose almost 540 percent. Stephan suggested that nationally in the 1973-75 time span, cost increases for energy were equivalent to the cost of 43,200 teacher positions.[3]

Another factor which may cause concern is the more than one-half of the existing schools which were built in the 1950s and 1960s. These schools were built during the period of rapid increase in the number of students enrolling and when school districts were primarily concerned with getting the housing for children, not quality buildings. A concept which has gained an important meaning for administrators is life cycle costing. In the 1950s and 1960s life cycle costs were not the most important concern for school

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[1]Stephan, "Impact of Rising Fuel Cost," p. 37.

[2]Paul Abramson, "Tenth Annual Maintenance and Operations Cost Study," American School and University 53 (March 1981): 58.

[3]Stephan, "Impact of Rising Fuel Cost," p. 37.

administrators.[1] Life cycle cost, which includes capital costs as well as operations and maintenance costs, is now one of the first considerations that is taken into account when new buildings or new pieces of equipment are considered.

Respondents to a survey of school administrators conducted by Stephan were asked their reasons for not taking action to solve their energy problems. They were encouraged to list all obstacles which would need to be surmounted prior to taking needed energy conservation steps. Having no funds to do needed repairs was the primary reason given by the administrators (60.8%). Next on the list was the fact that the buildings were old and very little could be done to improve their energy efficiency (54.8%). Lack of proper controls on heating and cooling systems was listed by just over half (50.6%) of the respondents as a deterent to saving energy. Almost half of the respondents (48.6%) listed leaky windows as something to overcome to save energy.[2]

The process of selecting a site and hiring a qualified architect can minimize school building energy use if proper attention is given to the selection process. Most areas have building codes which must be obeyed; however, in some cases going beyond the required design features can save substantial money for the district. One of the most ambitious plans calls for the use of an Energy Use Index (EUI) of 75,000 Btu per square foot for existing buildings and 55,000 Btu per square foot for new buildings.

The concept of Energy Use Index (EUI) allows comparisons to be made on the same basis regardless of energy source. The EUI concept uses an

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[1]Manfred Moses, "Beating the High Cost of Energy in Schools--Why It Must Be Done and How To Do It," The American School Board Journal 164 (April 1977): 28.

[2]Stephan, "Impact of Rising Fuel Cost," p. 37.

accepted engineering unit, the British thermal unit (Btu), as an aid in comparing fuels with various methods of measurement--gallons, cubic feet, kilowatt-hours, tons.

For example, comparable savings might be obtained by eliminating windows or by triple glazing them and then adding ceiling insulation. The index is used to examine the total energy requirement and to make possible comparisons from building to building. Current usage in schools ranges from 75,000 Btu to 500,000 Btu per square foot.[1] The median usage as shown in the American Association of School Administrator's study was 104,000 Btu in 1979.

If energy conservation is emphasized, the designer can be asked to present an energy use comparison based on certain design specifications. In selecting the heating, cooling, and ventilation system, there are a number of choices which can be made. Each system has relative advantages and a competent architect would be able to recommend the best one for saving energy in a specific school application.[2]

AASA concluded that reductions in energy consumption (down 38%) from 1973 to 1979 were due primarily to changes in operations, more energy conscious maintenance, and implementation of low cost retrofits.[3] Moses suggested that several schools have been able to save ten to fifteen percent in fuel costs. Some schools with very innovative approaches have reduced costs by as much as thirty percent. The difference between energy

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[1]James E. Piper, "The Energy Audit: What It Can Do for You," American School and University 50 (March 1978): 58.

[2]Ish Sud, "Principles of Heating, Ventilating, and Air Conditioning," In Short Course of Energy Conservation in Buildings, (Durham, N.C.: Duke University Center for the Study of Energy Conservation, 1977), p. 4.

[3]AASA Energy Use Study, p. 3.

consumption and cost savings is due to increases in the energy price. Moses contended that as much as fifty percent more energy could be saved if more than a superficial examination were made of the total problem. Moses stated that school administrators have not learned two "energy facts of life." These facts are that alternatives to current sources of energy are effectively years away, and cost for energy is rising and will continue to do so into the foreseeable future.[1] The differences between decrease in consumption and decrease in bills underscore the second idea.

Fredrickson suggested that major building renovation not be considered unless there is at least fifteen years of life left in the structure. He said that even minor renovation should not be done unless the building has five years of service remaining.[2]

Increased concern about the cost of energy and the cost of the improvements needed to lessen the use of energy have caused administrators to carefully examine the cost effectiveness of all modifications. One of the methods used is to calculate the payback period.

Payback period is the time needed to recover the capital cost plus interest from projects designed to produce energy savings. Payback periods will vary with the project but, generally they must be in the range of five to ten years to be considered cost effective. Payback calculations can be performed for any remodeling or renovation project to determine if the cost of the project is justified by the dollars saved.

One savings method concerns operational activities in the schools. Operational changes can be as simple as fuel contracts being based not on

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[1]Moses, "Beating Energy Cost," pp. 28-29.

[2]Fredrickson, "Facilities Recycling," p. 63.

gallons or cubic feet but on energy or Btu content,[1] or as complicated as changing the calendar of the school year. One method suggested by Eaton concerning school year modification may save energy. Eaton's approach was opposite from the proposal to close schools in cold winter months in order to save energy. His proposal was to close in the month of May. The reasoning is that heat must be supplied in all the winter months to prevent pipes from freezing, whether the building is used or not. May was chosen because no heat and little, if any, cooling would be required in the building during the spring.

Innovation in operations must be encouraged if costs are to be minimized in the short run. Long-term cost reductions can be realized through new, more efficient building and retrofit programs. When deciding to build a building, the initial cost as well as operating costs and potential energy savings must all be evaluated in order to optimize savings and costs.

Sufficient demonstration projects have been undertaken or are currently on the drawing board to give school administrators data for optimizing their decisions about school design. One large school project was built in Reston, Virginia. In addition to being solar, this building was built inside a hill and a heat reclamation system was installed. Not even considering savings from the solar component, up to 50 percent of the normal fuel costs have been saved with the other conservation features. The school's construction cost with the energy-saving features was still at the

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[1]Irving Fallon, "Save Money With This Fuel Oil Spec.," American School and University 50 (February 1978): 62.

national average of $34-$36 per square foot.[1] Energy saving features do not necessarily have to be more expensive as the Reston project demonstrates.

Two nearly identical schools built in essentially identical locations and with similar student populations showed a savings in initial capital costs when designed with energy conservation in mind. A summary of these savings is presented in figure 6.

Capital Savings Due to Insulation	
° delete 82 tons of air conditioning	$57,500
° reduced electrical requirements	4,900
	-62,400
Capital Costs Due to Insulation	
° urethane foam roof deck	27,000
° foam board walls	33,900
Net Capital Savings	$ 1,500

Fig. 6. Comparison of savings vs. costs in insulation[2]

In order to facilitate the development of the SRDAS, it was necessary to identify those elements in school building design that were similar from one situation to another. The uniqueness of school design lies in the similarities among buildings constructed during the same period. There have been three separate periods of design for school buildings in the state of North Carolina. The periods are pre-1950s, 1950-70, and 1970-81.

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[1]Gregg W. Downey, "Some Sunshine for Your Fiscal Life," The American School Board Journal 164 (August 1977): 56.

[2]Stanley O. Bokelman, "Savings Can Pay Cost of Insulation," American School and University 49 (July 1977): 24-25.

The typical design for the 1950-70 buildings is described in Figure 7. Buildings constructed during this period are the focus for SRDAS.

Corridor type - Central hall with classrooms on each side.
Roof type - either built-up asphalt roof or sloped roof over rafters.
Floor type - either slab-on-grade or concrete over steel joists.
Window type - single glazed in metal frames
Wall type - brick veneer over cinder block structure without insulation in cores.
Heating source - Most often oil or gas furnace. Occasionally electric furnace.

Fig. 7. Typical design considerations in North Carolina schools (1950-70)[1],[2]

Buildings constructed in the pre-1950s period were often two story designs with high ceilings, narrow halls, wooden floors, and a central stairwell. The buildings were typically not fire resistant. There was no insulation added to the building materials.

School design for the 1970-81 period was typically compact in structure. Hallways were eliminated where possible as were windows. Insulation was considered important in these buildings.[3]

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[1]Interview with Robert Bryan, North Carolina Division of Plant Operations, Raleigh, North Carolina, 19 November 1981.

[2]Interview with Darrell Spencer, North Carolina Division of School Planning, Raleigh, North Carolina, 9 December 1981.

[3]Ibid.

CHAPTER III

GOVERNMENTAL ACTIVITIES IMPACTING SCHOOL ENERGY USE

Energy policy interaction, particularly as it relates to school energy use, is an area which has received little study. Many of the same criticisms which apply to energy policy in general apply to educational energy policy in particular. Statements made relative to general energy demand, consumption, and resources need little or no modification to be applicable to school building energy use. Consider the following example:

> Even though many users have not actually experienced shortages, it is clear that there is widespread concern as to the dependability of fuel supplies, whereas in the past users generally have simply assumed that fuel would be available in the kinds and quantities required.[1]

This chapter is a report of the federal laws, federal regulations, state laws, and state regulations as they relate to energy conservation in the schools. Since energy policies, laws, and regulations are tied closely with state-of-the-art technology, the summary section is a presentation of possible energy options for schools.

Federal Law

Federal law relating to school energy conservation has primarily been contained in three separate bills. The first of the federal laws is the Energy Policy and Conservation Act (P.L.94-163), which was enacted in

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[1]Irving White, "Policy Making: Limitations of a Conceptual Model," Bulletin of the Atomic Scientist 27 (October 1971): 22.

1975[1]; the second act enacted in 1976, was the Energy Conservation and Production Act (P.L.94-385)[2]; the third act was the National Energy Conservation Policy Act (P.L.95-619), enacted in 1978.[3] These federal laws formed the legal undergirding for the national program of energy conservation.

The Energy Policy and Conservation Act (EPCA) dealt with the establishment of plans to help in energy conservation. Title II of this law dealt with energy plans which the President might suggest. Several admonitions to the President were contained within the body of this title. In general, any presidential plan must be specific in outlining the need for any action requested. Further, the executive must explain the rationale and the operation of the plan. An economic impact evaluation must also be filed "...to the extent practicable..." by the President.[4]

These requirements placed on the executive branch of the federal government an obligation to come up with plans and to evaluate the plans prior to their implementation. The economic evaluation was a specific requirement and perhaps portended a broad-view requirement for executive plans. Little or no state action was called for in Title II of EPCA. Some economic input from the state could be required, but basically Title II was directed toward federal action.

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[1]Energy Policy and Conservation Act, U.S. Code, vol. 42, Sec. 6201 (1975).

[2]Energy Conservation and Production Act, U.S. Code, vol. 42, Sec. 6801 (1976).

[3]National Energy Conservation Policy Act, U.S. Code, vol. 42, Sec. 8201 (1978).

[4]Energy Policy and Conservation Act, vol. 42, Sec. 6261.

Title III of EPCA was different from Title II. Title III required a high level of state action. Title III had a statement acknowledging a need for states to enact enabling legislation and a call for regulations to conserve energy.

A short statement in the title lauded the value of energy legislation/regulation.[1] After the acknowledgement of need and value of state action, section 6322 of Title III required states to establish energy conservation plans. Not only are the plans mandatory, but there was also a specific requirement for energy savings. This requirement was for a five percent savings in the projected energy demand for the states in 1980.[2]

A general plan was specified within the title. In subsequent paragraphs, there were some specific requirements as to the content of the state energy plans. Only those requirements with relevance to education will be considered. First, mandatory lighting standards were set for all public buildings. Second, mandatory standards and policies relating to energy efficiency considerations in materials procurement by states and their subdivisions were established. Third, mandatory thermal efficiency standards and insulation requirements for new and renovated buildings were set.[3]

The federal government gave permission for the states to include other energy saving features in their plans by paragraph d of section 6322 of Title III. States could, if they felt it to be desirable, impose restrictions on the hours of operation of public buildings as well as restrictions

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[1]Ibid., Sec. 6321.

[2]Ibid., Sec. 6322.

[3]Ibid.

on the conditions of operation of these buildings. Second, restrictions were placed on the use of decorative lighting. Programs of public education to promote energy conservation could also be included in the overall state energy plan. The final permission allowed any other appropriate program or method to conserve and improve energy conservation and efficiency.[1]

While EPCA Title III set up a procedure and outlined a general state energy plan for the states to adopt, a subsequent title (Title V) was specific in overruling any state law, program, rule, regulation, or order which would be in conflict with P.L.94-163. States could choose to go further than the federal requirement but only if their plans did not conflict with EPCA.[2]

Title III set requirements for the states and their subdivisions to meet in their energy plans. Choice was given for some program elements, but many were specified.

Reasons for all the specifics in this act (EPCA) could be justified if the act were placed in time context. A serious oil embargo had occurred two years earlier, and the country was just beginning to recover from the economic effects which resulted from the oil shutoff. The government appeared eager to prevent any serious economic consequences should another oil embargo occur.

The Energy Conservation and Production Act (ECPA) was the second major piece of energy legislation from the 94th Congress. As stated in the preamble to this act, its purposes were:

> To amend the Federal Energy Administration Act of 1974; to extend the duration of authorities under such Act; to provide an incentive for

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[1]Ibid.

[2]Ibid. Sec. 6396.

domestic production; to provide for electric utility rate design initiatives; to provide for energy conservation standards for new buildings; to provide for energy conservation assistance for existing buildings and industrial plants; and for other purposes.[1]

Within the act were suggestions for school administrators to consider when planning. Title III enumerated several "findings of fact" concerning new buildings. One finding was that large amounts of energy are used each year in the processes of heating, cooling, ventilating, and providing hot water for buildings lacking adequate energy conservation. A second finding was that implementation of federal performance standards for new buildings can prevent energy waste. The third finding was that failure to provide adequate energy conservation measures in newly constructed buildings increases long-term operating costs and may impinge upon the ability to repay loans made, insured, or guaranteed by federal agencies. In addition, the value of these buildings as collateral is diminished. Another finding concerned using state and local building codes to insure adequate conservation measures without a great deal of direct federal interference.[2]

In addition to the findings of fact, the following three direct purposes of Title III were enumerated:

1. Redirect federal policies and practices to assure that reasonable energy conservation features will be incorporated into new commercial and residential buildings receiving federal financial assistance;

2. Provide for the development and implementation, as soon as practicable, of performance standards for new residential and commercial buildings which are designed to achieve the maximum practicable improvements in energy efficiency and increases in the use of non-depletable sources of energy; and

3. Encourage states and local governments to adopt and enforce such standards through their existing building codes and other

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[1]Energy Conservation and Production Act, Sec. 6801.

[2]Ibid., Sec. 6831.

construction control mechanisms or to apply them through a special approval process.[1]

To prevent misinterpretations, the act included a list of important definitions as they related to the formulation of law. Several of the more important definitions, and those, perhaps, most open to misdefinition, are listed below:

1. The term "building" means any structure to be constructed which includes provision for a heating or cooling system, or both, or for a hot water system;

2. The term "building code" means a legal instrument which is in effect in a state or unit of general purpose local government, the provisions of which must be adhered to if a building is to be considered to be in conformance with law and suitable for occupancy and use;

3. The term "commercial building" means any building other than a residential building, including any building developed for industrial or public purposes;

4. The term "Federal agency" means any department, agency, corporation, or other entity or instrumentality of the executive branch of the Federal Government, including the United States Postal Service, the Federal National Mortgage Corporation; and

5. The term "Federal building" means any building to be constructed by, or for the use of, any federal agency which is not legally subject to state or local building codes or similar requirements.[2]

Congress, as stated in the act, found that the fastest and most cost-effective way to reduce American dependence on imported energy would be to encourage and facilitate energy conservation and renewable energy measures for existing buildings. Not only would such a program help reduce energy dependence, it would also be environmentally sound. Major programs might be needed and should be undertaken to assure that the retrofit and neofit applications occur.

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[1]Ibid.

[2]Ibid., Sec. 6832.

In addition, Congress found that procedures were deficient due to a lack of available and adequate financing. A shortage of reliable and impartial information concerning savings if particular projects were to be undertaken was another deficiency. A third area of deficiency was the absence of organized programs which could provide information about projects and their economic value.

If major programs of financial incentives and assistance existed for energy conservation measures, Congress found that there would be a significant drop in the nation's oil imports because of the drop in energy demand. These money programs would also help to ameliorate the impacts of high price energy supplies for those who could not afford the capital investment. A corollary benefit of money programs would be the creation of jobs and a generally healthier economy.

While Congress provided a federal initiative for action, it appeared to recognize the value of local implementation. Support for this interpretation can be seen in section 6851 of the Energy Conservation and Production Act.

> ...the diversity of conditions among the various states and regions of the nation is sufficiently great that a wholly federally administered program would not be as effective as one which is tailored to meet local requirements and to respond to local opportunities....[1]

The Energy Conservation and Production Act (ECPA) was passed to supplement the earlier Energy Policy and Conservation Act. The statement at the end of Title IV of ECPA was indicative of the federal government's position:

> It is therefore, the purpose of the act to encourage and facilitate the implementation of energy conservation measures and renewable-

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[1]Ibid., Sec. 6851.

resource energy measures in dwelling units, nonresidential buildings, and industrial plants....[1]

These purposes were to be accomplished through supplemental state energy conservation plans and federal financial incentives and assistance.

The last of the three primary bills was the National Energy Conservation Policy Act (P.L.95-619).[2] This bill, in its impact on schools, differed from either EPCA or ECPA by providing money directly to the states to initiate energy conservation procedures. The act had several titles but only Title III dealt with schools.

The purpose of Title III, according to section 6371, was to authorize monetary grants to the States and to public and non-profit schools and hospitals. The money was to be used in assisting states and their subunits, as well as private, non-profit schools and hospitals, in identifying and implementing maintenance and operating procedures which would conserve energy. Provisions for evaluating, acquiring, and installing energy conservation measures to reduce energy use were also within the purview of the National Energy Conservation Policy Act. Energy cost reduction for schools and hospitals was also a purpose for the act.

Four findings of fact by the Congress were listed in the act. These findings were:

(1) the Nation's nonrenewable energy resources are being rapidly depleted;

(2) schools and hospitals are major consumers of energy, and have been especially burdened by rising energy prices and fuel shortages;

(3) substantial energy conservation can be achieved in schools and hospitals through the implementation of energy conservation maintenance and operating procedures and the installation of energy conservation measures; and

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[1]Ibid., Sec. 2809.

[2]National Energy Conservation and Policy Act, vol. 42, Sec. 8201.

(4) public and nonprofit schools and hospitals in many instances need financial assistance in order to make the necessary improvements to achieve energy conservation.[1]

A portion of Title III of the National Energy Conservation Policy Act was an amendment to the Energy Policy and Conservation Act (P.L.94-163). The amendment was in the form of an addition and had as its primary purpose the provision of money for energy improvements.

The amendment enumerated a number of items which were eligible for funding. Any building which included a heating or cooling system, or both, and was completed on or before 20 April 1977 was covered by the amendment. Energy conservation measures -- meaning installation or modification of an installation in a building -- must have as the primary intent the reduction of energy use or the use of an alternative energy source. These measures, as described in the act, included, but were not limited to, the insulation of the structure or its systems; the addition of storm doors and windows or other multi-glazing or heat reflecting systems; the addition of automatic energy control systems and the subunits needed for these systems to operate steam, hydraulic, or ventilating controls; and the addition of equipment for solar water heating, space heating or cooling, or solar electric generation. The replacement of boilers or modifications designed to make the operation more energy efficient was also within the scope of the amendment. Other conservation measures such as weatherstripping, caulking, energy recovery systems, and cogeneration systems were listed.[2]

If a school district could identify methods of conserving energy which were not enumerated in the amendment, these methods could still be

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[1]Ibid., Sec. 6371.

[2]Ibid.

qualified. The specific requirements for federal funding were described in the act.[1]

Part 2 of Title III is a description of the available federal funding. In this part the purpose as stated was to

> ...authorize grants to states and units of local government and public care institutions to assist them in conducting preliminary energy audits and energy audits in identifying and implementing energy conservation maintenance and operating procedures and in evaluating energy conservation measures to reduce the energy use and anticipated energy costs of buildings owned by units of local government and public care institutions.[2]

The purpose for the National Energy Conservation Policy Act was based on four concepts. The first concept was that of finite energy resources and their rapid depletion. Second, buildings owned by units of local government were large consumers of energy and had ever-increasing costs and potential shortages of fuel. Closely tied to the second concept was the fact that major energy conservation can be achieved in public buildings through implementation of energy conservation maintenance and operating procedures. Energy audits and their high costs formed the basis for the last concept. Audits, while potentially very valuable in identifying energy waste, were so expensive that many local governmental units needed financial assistance in order to conduct an audit. Evaluating the potential benefits of following through on the audit was also expensive and might not occur without financial assistance.[3]

Audits were lauded in Title III as an appropriate method of finding not only where energy waste was occurring, but also where savings could be

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[1]Ibid.

[2]Ibid., Sec. 6372.

[3]Ibid.

made. The language within the act set forth criteria which audits must meet in order to be eligible for federal funding. Within the framework of the audit criteria and goals, the Secretary of the Department of Energy would be able to determine "hardship" cases. The basis for hardship cases would be climate, fuel costs, fuel availability, local financial status, and other such factors as were deemed important by the Secretary.[1]

Although audits were singled out as being especially useful in most cases, they were generally not eligible for total federal funding. Section 6371 did, however, allow the Secretary of the Department of Energy to make grants to the states for the total cost of conducting preliminary audits.[2]

Within the act were requirements which states must follow when requesting financial aid. State plans should include the results of audits and estimates of savings if the proposed energy conservation measures were implemented. The audit should include recommendations as to the types of energy conservation projects. State plans must provide for an equitable distribution of dollars among the subunits of the state based on size and relative needs. A guarantee that federal dollars were to be used as supplemental funds and not replacement funds was required under the guidelines.[3]

Two other general criteria were listed in section 6371. One of these criteria was that an organization could make only one application for funding each year. The other criteria was that state boards of education must approve any local school project before the federal government would

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[1]Ibid., Sec. 6371.

[2]Ibid.

[3]Ibid.

fund the project.[1] An important aspect in funding was that only fifty percent of a project's cost would be borne by the federal grant. If a preliminary audit were totally funded, this funding was to be taken into account when figuring the amount available for the project.[2]

North Carolina's Department of Public Instruction hired a consulting group, the Council of Educational Facility Planners, to develop a plan which would meet the requirements of the National Energy Conservation Policy Act. The members of the Council determined that applications for technical assistance would be based on the potential savings and on fuel type and cost, as well as total consumption.[3]

The Council enumerated eleven legal requirements of the federal act which must be considered. These requirements are listed below:

1. the agency filing must have legal authority to file;
2. the project must comply with Title VI of the Civil Rights Act (P.L.88-352);
3. the project must comply with the Uniform Relocation Assistance and Relocation Act (P.L.91-646);
4. access to the project books must be available;
5. compliance with the Hatch Act;
6. compliance with the Fair Labor Standards Act;
7. compliance with all Environmental Protection Agency regulations;
8. compliance with the Flood Disaster Protection Act (P.L.93-234);
9. compliance with the National Historic Conservation Acts of 1966 and 1971;
10. compliance with all requirements of the federal sponsoring agency; and
11. the prohibition of unfair gain by employees.

In addition to the eleven specific items an agency applying for funds would have to comply with other federal regulations as related to

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[1]Ibid.

[2]ibid.

[3]Council of Educational Facility Planners, International, "Proposed North Carolina State Plan for the National Energy Conservation Policy Act of 1978," mimeographed paper, 20 October 1979, pp. 20-21.

application, acceptance, and use of federal funds in a federally assisted program.[1]

The State of North Carolina, through its energy plan, listed seventeen other provisions which became a part of the grant procedure. These provisions were an integral part of the proposal prepared by the Council of Educational Facility Planners, International.

Provision one, according to federal rules and regulations, was:

> A statement setting forth the procedures by which the views of eligible institutions or state-wide organizations representing such institutions, or both, were solicited and considered during development of the State Plan.

Pursuant to the first provision, the Energy Division of the North Carolina Department of Commerce sought the advice from the identified eligible institutions and their representatives. The input from these individuals and institutions was embodied in the final version of the proposed State Plan which was submitted on 22 October 1979.[2]

Provision two was:

> The procedures the State will follow to notify eligible institutions and coordinating agencies of the content of the approved State Plan.

This provision required the distribution of a number of copies of the plan to libraries, newspapers, and other locations where eligible agencies could become aware of the provisions. In addition, the proviso for workshops, conferences, and seminars was included to respond to queries on the State Plan.[3]

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[1]Ibid., pp. 55-59.

[2]Ibid., pp. 1-2

[3]Ibid., pp. 3-4.

The third provision described:

> The procedures for submittal of grant applications to the state....

Included in the requirements for the proposal were Energy Audit Report forms and Technical Assistance Report forms.[1]

Provision four listed:

> A description and evaluation of the results of preliminary energy audits which have been conducted in the state....

Preliminary energy audit questionnaires were mailed to a number of institutions and their responses were sampled to give an overall view of their current energy use. Figure 8 shows the North Carolina public elementary and secondary schools' energy consumption by type of energy and amount of use.

Number of Institutions (Sample): 50
Number of Institutions (Total): 2,422
Electricity: 982.01×10^{10} Btu
Coal: 24.50×10^{10} Btu
#5 Oil: 5.99×10^{10} Btu
#2 Oil: 417.46×10^{10} Btu
Natural Gas: 87.36×10^{10} Btu
Water Heating and Cooling: 15.57×10^{10} Btu
Total: 15.32×10^{12} Btu
Btu Per Gross Square Foot Per Year: 113,000 Btu
Cost Per Gross Square Foot Per Year: $0.34

Fig. 8. Energy audit data from North Carolina public schools (K-12) in 1979[2]

According to Federal Rules and Regulations, the fifth provision included in the North Carolina State Plan consisted of:

> The procedures to be used by the State for evaluating and ranking technical assistance and energy conservation measure grant applications...including the weights assigned to each criterion....

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[1]Ibid., p. 5.

[2]Ibid., pp. 8-9.

The Energy Division in North Carolina set three procedural steps to insure compliance. These steps were administrative review, technical review, and final evaluation and ranking. The administrative review dealt with the completeness of the application, the technical review with the engineering feasibility of the proposal, and ranking with the relative merit of the proposal based on current goals and objectives.[1]

The sixth provision included in the North Carolina State Plan consisted of:

> The procedures that the state will follow to insure that funds will be allocated equitably within the State, including procedures to insure that funds will not be allocated on the basis of size or type of institution but rather on the basis of relative need taking into account such factors as cost, energy consumption, and energy savings....

Three great categories were identified to insure equitable distribution of funds. Two of these categories dealt with technical assistance study grants to units of local government, public care institutions, schools, and hospitals. The third group was reserved for implementing energy conservation measures in schools and hospitals.[2]

The seventh provision included in the plan consisted of:

> The procedures that the state will follow for identifying schools and hospitals experiencing severe hardship and for apportioning the funds that are available for schools and hospitals in a class of severe hardship.

Within this provision, there were two specific requirements. The first requirement was the establishment of criteria used to identify severe economic hardship; the second requirement was the determination of the level of funding for which the applicant would qualify.

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[1]Ibid., pp. 13-22

[2]Ibid., pp. 36-37

Federal restrictions governing the hardship funding required that certification not be made prior to rankings for the matching funds certification. After those institutions which qualified for the matching funds were ranked, they could then be considered for hardship cases.

The State Plan interpreted the federal regulations governing hardship as follows:

> The Secretary may award 10 percent of the total amount allocated to a state for schools and hospitals for technical assistance and energy conservation measures in a given grant program cycle to cover more than 50 percent, but not to exceed 90 percent, of the cost of a technical assistance program or an energy conservation measure. These additional amounts may be awarded to applicants in a class of severe hardship, ascertained by the state in accordance with the State Plan for buildings....

For elementary and secondary schools, the criterion for severe hardship was based upon a Wealth Index. Wealth Index was to be figured based on a ratio of property value, sales tax, and general fund indices.

The various indices were defined as:

> property value index is the ratio of assessed property valuation per student for a given county,
>
> sales tax index is the ratio of collected sales tax per student, and
>
> general fund index is the ratio of county contributions to the state general fund (income tax) per student.

The formula uses 78 percent of the property value index plus 22 percent of the sales tax index and multiplies this figure by 50 percent of the general fund index.

If the Wealth Index were equal to 0.453 or less, the applicant would qualify for 90% of the total funds needed. If the Wealth Index were 3.480 or greater, no hardship funds could be granted.[1]

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[1]Ibid., pp. 42-49.

The eighth provision included in the North Carolina State Plan consisted of:

> A Statement setting forth the extent to which, and by which methods, the State will encourage utilization of solar space heating, cooling, and electric systems, and solar water heating systems.

A desire to encourage the use of solar energy techniques led the state to apply this provision to grant proposals. The State Plan of 1979 called for proposals which included solar energy aspects to be ranked according to their viability. Amount of insulation, type of fuel currently used for space heating and water heating, and general building characteristics each formed part of the relative importance ranking scheme.[1]

The ninth provision included in the North Carolina State Plan was a statement of:

> The procedures to assure that all financial assistance under this part will be expended in compliance with the requirements of the State Plan, in compliance with the requirements of this part, and in coordination with other state and federal energy conservation programs.

This section required the applicant to meet all criteria to insure non-discrimination.[2]

The tenth provision included in the North Carolina State Plan was a statement of:

> The procedures to insure implementation and continued use of energy conservation maintenance and operating procedures in those buildings for which financial assistance is awarded under this part.

Energy conservation maintenance and operating procedures were defined as:

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[1]Ibid., pp. 50-51.

[2]Ibid., p. 55.

> Modification in the maintenance and operations of a building, and any installation therein, which are designed to reduce the energy use in such building and which require no significant expenditure of funds.[1]

To facilitate the compliance with this provision, the Energy Division was required to comply with the following six procedural guidelines:

1. Require energy audit reports and technical assistance reports to be submitted with grant applications under this act.
2. Require grant applicants to assure, in writing, that appropriate energy conservation maintenance and operating procedures have been or will be followed.
3. Require experts certify those operational and maintenance procedures to be implemented.
4. Monitor annual energy usage of eligible facilities.
5. Make on-site inspections during construction and upon completion of construction of at least 5% of those institutions receiving funding.
6. Encourage the institutional staff to conduct energy audit updates on an annual basis.[2]

According to Federal Rules and Regulations, the eleventh provision included in the North Carolina State Plan required the following statement:

> The procedures designed to insure that financial assistance under this part will be used to supplement, and not supplant, state, local, or other funds.

Spot checks to assure compliance were to be conducted among the grantees; random selection of those grantees to be spot checked would insure that all categories of grantees were equally represented in the sample.[3]

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[1]Ibid., p. 60-61.

[2]Ibid.

[3]Ibid., pp. 63-65.

According to Federal Rules and Regulations, the twelfth provision included in the North Carolina State Plan was a statement of:

> The procedure for determining that energy audits performed without the use of federal funds have been performed in substantial compliance with all appropriate federal requirements....

To assure that energy audits had been performed in compliance with federal rules, the Energy Division formulated a specified energy audit format, identification of the person completing the audit, and review of the audit reports by a committee representing the Division and the affected institutions (schools, hospitals, public care facilities, etc.)[1]

According to Federal Rules and Regulations, the thirteenth provision included in the North Carolina State Plan consisted of:

> The procedures for establishment of, and adherence to, milestones for accomplishment of technical assistance programs and energy conservation measures receiving financial assistance under this part.[2]

According to Federal Rules and Regulations the fourteenth provision included in the North Carolina State Plan was a statement of:

> The procedures for determining that technical assistance programs performed without the use of federal funds have been performed in compliance with the federal requirements for the purposes of satisfying the eligibility requirements....[3]

According to Federal Rules and Regulations, the fifteenth provision included in the North Carolina State Plan consisted of:

> The procedures for State management, financial audit, monitoring and evaluation of technical assistance programs and energy conservation measures receiving financial assistance under this part.

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[1]Ibid., pp. 66-67.

[2]Ibid., p. 68.

[3]Ibid., p. 74.

This provision of the State Plan addressed the issue of the Energy Division's responsibilities after grants have been awarded by the U.S. Department of Energy to eligible institutions for technical assistance and energy conservation measures. Regulations required four administrative elements, overall project management, financial auditing, monitoring, and evaluation.[1]

According to Federal Rules and Regulations, the sixteenth provision included in the North Carolina State Plan was:

> A description of the State's program for establishing and insuring compliance with qualifications for technical assistance analysts.

The Energy Division required technical assistance analysts in the State of North Carolina to have experience in energy conservation and be a registered professional engineer licensed under the regulatory authority of the state of North Carolina; or be an architect-engineer team, the principal members of which are licensed under the regulatory authority of the state.[2]

According to Federal Rules and Regulations, the seventeenth provision included in the North Carolina State Plan was a description of:

> The procedures for apportionment of funds among eligible institutions within the State. As a minimum, such policies and procedures shall assure a separate priority ranking... for each building covered by an application approved... for:
>
> 1. Technical assistance programs for units of local government and public care institutions;
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> 2. Technical assistance programs for schools and hospitals; and
>
> 3. Energy conservation measures, including solar and other renewable resource measures, for schools, and hospitals.[3]

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[1]Ibid., p. 76.

[2]Ibid., p. 81.

[3]Ibid., p. 85.

The federal dollars provided through the National Energy Conservation Policy Act (P.L.95-619) have influenced the State Plan.

The supremacy of the federal government in energy matters became apparent through issuance of executive orders. In 1979, President Jimmy Carter ordered temperature restrictions in all public buildings including schools. The restrictions carried with them both civil and criminal penalties for violation.[1]

Rule making does, on occasion, allow for citizen input. In the 7 February 1980 Federal Register, a proposal for a Federal Standby Emergency Energy Conservation Plan was reported. The proposal included a number of energy saving alternatives. Only one, temperature restraint, would have directly impacted schools. Additional measures were considered, and one of these, school schedule modification, had potential for impact on schools. This proposal was to compress the five-day school week into four days. The lost instructional time could be made up by longer days and use of vacation periods. Vacation periods could also be extended during periods of high energy demand.[2]

At least two different opinions existed as to whether school schedule alterations, as proposed by the Department of Energy, would have an impact on energy conservation. Shirley Hansen, speaking for the American Association of School Administrators, criticized school closings for energy savings. Among the reasons she cited were:

1. Schools have already reduced energy use by thirty-five percent in five years and should be exempt from prescriptive guidelines.

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[1]U.S., President, Executive Order, "Emergency Building Temperature Restrictions," Federal Register 44 (5 July 1979): p. 39355.

[2]U.S., Department of Energy, "Proposed Standby Federal Emergency Energy Conservation Plan," Federal Register 45 (7 February 1980): passim.

2. Schools must be heated somewhat to keep pipes from freezing, and studies have shown that the extra heat needed to make the building comfortable is often marginal.
3. Closing schools on Friday would result in students being home to raise the thermostats, cook lunch, turn on televisions, or to drive around in their cars.[1]

Carsie Denning conducted a survey in North Carolina in the winter of 1978 which indicated that if schools were closed, more energy would be consumed in the homes. According to Denning, if the purpose is to save energy, school closings would be counter-productive. The small research project, conceived by Denning and conducted by students and school personnel, was not conclusive. Some of the school closings showed energy savings while others showed greater energy use.[2]

James R. Cox asserted that part of the energy use problem was due to the overdesign of buildings. Citing the use of air conditioning in elementary schools which operate from 8:00 or 9:00 to 2:00 and with a clientele not caring about warm temperatures, Cox provided evidence for his argument that schools are overdesigned.[3]

Limits to the overdesign of schools have been federally mandated through the Energy Policy and Conservation Act and the Energy Conservation and Production Act. Provisions in these acts, requiring the adoption of state standards for energy conservation through building codes, had potential to affect school overdesign.

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[1]"Energy Saving Plan Questioned by AASA," Education USA 22 (24 March 1980): p. 231.

[2]Carsie Denning, Personal Communication, 15 March 1980.

[3]Shirley B. Neill, School Energy Crisis, (Sacramento, CA: Education News Service, 1977), p. 23.

North Carolina adopted a building code based on energy conservation criteria. Those parts of the code which deal with school energy consumption are covered in Chapter XXXII of the building code and more specifically sections 3202.1 through 3202.9 within the chapter.

The first section of the 1978 code identified the groups which are covered by the requirements of the code. In addition to schools, other groups included in the section are business, mercantile, institutional, assembly, factory, industrial, and storage buildings. The type of building is important, but the size must also be considered in complying with the code. A building of 15,000 square feet or less could meet either prescriptive or performance criteria. Prescriptive criteria mean that insulation of windows, doors, and walls is prescribed. Performance criteria allowed the choice of several alternatives as long as the insulating values can be met. Buildings larger than 15,000 square feet had to comply with the performance criteria. The specifics of prescriptive criteria are illustrated in figure 9. If additions are made to existing structures, only the additions were required to comply with the code.

Buildings must be designed on the basis of activities or processes carried on or the equipment installed. If exceptions are granted to the architect for design load limitations, the designer is required to meet the prescriptive requirements found in section 3202.8 and the "Thermal Envelope Criteria" form must be submitted.[1]

Section 3202 was comprised of a number of definitions. The terms coefficient of heat transmission, building envelope, and process

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[1]North Carolina Department of Insurance, "Efficient Energy Utilization in New Building," North Carolina State Building Code, Volume I-General Construction, (Raleigh, N.C.: N.C. Department of Insurance, 11 September 1979), Sections 3202.1, a-d.

related energy are listed with their definitions as they relate to the code.

1. Coefficient of heat transmission - time rate of heat flow expressed in Btu/hr/ft^2/°F difference. This is also called the "U-value."
2. Building envelope - the walls, windows, ceilings, and doors which enclose the structure.
3. Process related energy - energy expended for some other purpose than general occupancy purposes.[1]

Section 3202.3 was also definitive. This section listed the four climatic zones within the state. These zones are important because of their relationships to both the prescriptive and performance criteria. Counties located within each zone are shown in figure 10.

State action has not been limited to formulation and implementation of the state plan or changes in the building codes. There are a number of public laws which have been passed by the legislature over the years, which contribute to energy usage or savings in the schools. The next section deals with each of the laws and assesses potential impacts. Only laws affecting school buildings and their operations are listed.

This section cites specific parts of North Carolina State law by section number (i.e. §115-114). The reference used is one to which most school administrators have easy access. The citation form is also familiar to most school administrators.

§115-36 - A normal school day is to consist of a minimum of six hours except for handicapped students and those students from kindergarten through the third grade. The specific hours of school operation are left to the

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[1]Ibid., Sec. 3202.2.

(a) General

The stated U-value of any one assembly, such as roof, ceiling, wall, or floor may be increased and the U-value for other components decreased, provided that the overall heat loss from the entire building envelope does not exceed the total resulting from the conformance to the stated U values

(b) Wall Thermal Performance

The gross area of exterior walls shall have a combined thermal transmittance value (U) not exceeding 0.280 Btu/hr/sq. ft.

(c) Roof Thermal Performance

The gross area of building roof shall have a thermal transmittance value not exceeding the values listed in Table A. Where return air ceiling plenums are utilized, the thermal transmittance of the ceiling shall not be considered.

ROOFT WGT. (LB/SF)	ZONES I AND II	ZONE III	ZONE IV
0-10	0.098	0.089	0.084
11-50	0.105	0.094	0.087
51+	0.113	0.099	0.092

(d) Floors Over Unheated Spaces

The floor of a conditioned space located over an unconditioned space or outdoors, shall have a thermal transmittance value not exceeding 0.14 in Zone I and II, 0.11 in Zone III, or 0.08 in Zone IV.

(e) Slab-On-Grade-Floors

Slab-on-grade-floors shall be insulated around the perimeter of the floor with rigid-type insulation having minimum "R" value of 3.75 and specifically designed and recommended by the manufacturer for this service. The insulation shall extend downward from the top of the slab for a minimum distance of 24 inches or downward to the bottom of the slab then horizontally beneath the slab for a minimum total distance of 24 inches.

Fig. 9. Prescriptive criteria for buildings in North Carolina[1]

[1]Ibid., Sec. 3202.9

Zone I	Beaufort	Dare	Lenoir	Robeson
	Bladen	Duplin	New Hanover	Sampson
	Brunswick	Hoke	Onslow	Scotland
	Carteret	Hyde	Pamlico	Tyrell
	Craven	Jones	Pender	Washington
	Columbus			
Zone II	Alamance	Currituck	Johnston	Pitt
	Alexander	Davidson	Lee	Polk
	Anson	Davie	Lincoln	Randolph
	Bertie	Durham	Martin	Richmond
	Burke	Edgecombe	Mecklenburg	Rowan
	Cabarrus	Franklin	Montgomery	Rutherford
	Caldwell	Gaston	Moore	Stanly
	Camden	Gates	Nash	Union
	Caswell	Granville	Northampton	Vance
	Catawba	Greene	Orange	Wake
	Chatham	Halifax	Pasquotank	Warren
	Chawan	Harnett	Person	Wayne
	Cleveland	Hertford	Perquimans	Wilson
	Cumberland	Irdell		
Zone III	Buncombe	Guilford	Madison	Surry
	Cherokee	Haywood	McDowell	Transylvania
	Clay	Henderson	Rockingham	Wilkes
	Forsyth	Jackson	Stokes	Yadkin
	Graham	Macon	Swain	
Zone IV	Alleghany	Avery	Watauga	
	Ashe	Mitchell	Yancey	

Fig. 10. N.C. Counties listed by their thermal zone location.[1] Zone I counties are warmest and Zone IV counties coldest.

local board. A school term is to consist of 180 days and no more than 60 days may be suspended by the state superintendent.[2]

This section limits the flexibility of local administrators to develop new calendars or schedules. The statute does not give educational reasons for the six hours per day, nor for the one-hundred-eighty days per year.

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[1]Ibid., Sec. 3202.3.

[2]North Carolina State Board of Education, Public School Laws of North Carolina, (Charlottesville, Va.: Michie Company, 1978), p. 42.

This provision might be changed if any innovative methods outside the legal mandates prove useful.

§115-71.6-115-73.12 - A purpose of the Community Schools Act is to encourage greater community involvement in public schools and greater use of public school facilities.[1]

The provisions in the Community Schools Act (§115-73), if implemented, can greatly add to the local school unit's energy cost. If the community does, indeed, make greater use of the physical plant for night and weekend meetings, the normal control procedure for heating and cooling will have to be altered. These off-school hours will cause the consumption of more energy. As more school systems adopt computer modeling to compare energy use, community use must be factored in for a true picture of cost per instructional hour, or per pupil, or some other quantifier.

§115-76 - This section has a list of the reasons for consolidation of schools and the discontinuance of schools. The only reason which is related to energy use is transportation costs.[2]

This provision of North Carolina state law prevents energy from being considered in school closing decisions except as related to transportation. Energy use in buildings, even excessive use, is not addressed in this statute.

§115-100.6 - Budget is the topic of this section. Authorization for expenditures not in conflict with State Board policies or local board policies is granted.[3]

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[1]Ibid., p. 57.

[2]Ibid., pp. 62-63.

[3]Ibid., pp. 67-68.

Provisions in this section make possible the expenditure of state funds for various types of increased energy costs. As long as energy use does not exceed the guidelines set by either the state or local board, payments for its use may continue. In theory, at least, the State Board could prohibit a large amount of non-essential energy use through a simple board policy.

§115-129 - The duty of boards of education to provide for the nine months school term is clear and requires suitable buildings, equipment, and furniture. School boards must assure compliance of the buildings to applicable provisions of the North Carolina State Building Code and local buildings and electrical codes.[1]

The provisions of §115-100.6 authorized funds for building operations. This section required such expenditures to assure safe condition in the buildings. Compliance with both state and local building codes may, over the long term, have considerable impact on total energy consumption.

§143-129 - When letting bids the "... award shall be made to the lowest responsible bidder or bidders, taking into consideration quality, performance, and the time specified in the proposal for performance of the contract."[2]

Section 143-129 has provided a method for not accepting the lowest bid for buildings. If the school board desires, the "... consideration of quality, performance..." is a way to get better, more energy efficient construction.

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[1]Ibid., pp. 100-102.

[2]Ibid., p. 426.

A number of laws can impact the schools and their operations from an energy standpoint. The laws cited have the potential for use by a local administrator to substantially affect district energy costs.

When school boards adhere to operational regulations set forth by the State Board of Education, they will likely reduce the number of additional dollars needed to keep up with rising costs.

There were ten regulations adopted by the board in 1979 which, if followed, would limit the total energy used in the schools.

COMFORT TEMPERATURE SETTINGS - (Grades 7-12 and Institutions of the Community College System) - Space temperature settings will insure that no energy consuming assistance will be provided to obtain a temperature of more than 65°F during the heating season and less than 78°F during the cooling season.

(Grades K-6) - Space temperature settings will be determined by appropriate LEA personnel so as to provide the minimum acceptable temperature during the heating season and for the maximum acceptable temperature during the cooling season. Such things as degree of activity, type of floor, age of occupants, unusual health situations and other factors should be considered in determining acceptable temperature settings.

DOMESTIC HOT WATER TEMPERATURE SETTINGS - Domestic hot water being used for anything other than dishwashing will not be provided at temperatures greater than 105°F. Hot water being used for dishwashing purposes will be heated so as to provide the most efficient use of energy in obtaining the necessary temperature. Consideration will be given to the heating of water that may provide water in excess of 140°F before entry into the dishwasher booster depending upon the electrical power rate schedule.

UNOCCUPIED PERIOD TEMPERATURE SET-BACK - Methods will be provided to assure that no energy consumption will be maintained except for necessary building protection during all unoccupied hours. Program clocks or more sophisticated controls will be employed for this purpose. These settings will be for no more than 50°F during the heating season.

ENERGY SOURCES - The use of natural gas, wood, and coal will be used where possible for comfort and water heating for conversions, replacements, or additions.

COMMUNITY USE OF FACILITIES - Administrative units will establish policies relating to energy use for community use of school facilities. Consideration for these policies will take into account maximum use of residual heat from day occupancy without supplemental heating or cooling for night occupancy.

GYMNASIUM USE - Neither heating nor cooling will be maintained in gymnasiums for non-school hours unless scheduled activities are taking place in which teams or large portions of teams are involved.

COMPUTERIZED MONITORING AND REPORTING PROGRAM - Each administrative unit and each institution of the Community College System will participate in the state-wide computerized energy monitoring and reporting program being conducted by the Division of Plant Operation of the Controller's Office.

ADMINISTRATIVE UNIT ENERGY MANAGEMENT PROGRAMS - Each administrative unit and each institution of the Community College System will prepare in writing an energy management program that will include all sectors of operation. Copies of these written programs will be available to the State Board of Education upon its request.

ELECTRICAL LOAD MANAGEMENT - Administrative units and Institutions of the Community College System having all-electric facilities will make a thorough study of the existing electric power rate schedule for each facility and prepare a written electrical load management program for each facility that will include operation of cafeteria, athletic facilities, auditoriums, and classroom areas.

COMPLIANCE - The Division of Plant Operation shall develop detailed instructions to insure compliance with these rules and regulations.[1]

Another action which showed it could affect energy use was the federal executive order limiting temperatures in public buildings to 65°F in winter and 78°F in summer. (Elementary schools were exempted from compliance and penalties).[2]

Laws, regulations, board actions, and executive orders have the potential for a large impact on the schools. Administrators need to be aware of what these possible areas of influence are, and how to minimize their economic impact on the system. One area where administrators need to become better informed deals with the rate structures of the utilities. Electric utilities will be used as a example. At times, the criticism of

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[1]"N.C. School Plant Conservation Policy," (Raleigh, N.C.: N.C. Board of Education, 2 August 1979), passim.

[2]U.S. President, Executive Order, "Emergency Building Temperature Restrictions," Federal Register 44, no. 130, 5 July 1979, p. 39355.

rate structures being written for engineers, seems valid. Take for example, the statement from the Carolina Power and Light Rate Book:

> The Billing Demand shall be the maximum KW registered or computed, by or from Company's metering facilities, during a 15-minute interval within the current billing month. However, the Billing Demand shall not be less than the greater of (1) 80% of the maximum monthly 15-minute demand during the billing months of July through October of the preceding eleven billing months or (2) 60% of the maximum monthly 15-minute demand during the billing months of November through June of the preceding eleven billing months or (3) 75% of the Contract Demand until such time as the Billing Demand first equals or exceeds the effective contract Demand, or (4) 50KW.[1]

The North Carolina Department of Public Instruction has a Division of Plant Operations which can help systems understand fuel use, costs, and conservation techniques. This division operates for all districts but is particuarly important for smaller systems which cannot afford to have on staff a full time energy expert. The Division of School Planning serves a similar purpose in the area of new plant design.

One of the advantages of using the computer modeling and analysis presented in chapter IV is the available expert advice and the ability to consider several alternatives to an energy problem. While this information can probably be obtained from appropriate state agencies, it is not always available in as timely a fashion as the administrator may desire. Use of the computer program SRDAS is an effective and efficient method for analyzing alternatives to school energy savings.

Not all regulations affecting North Carolina school energy use come from the board of education. Some regulatory agencies can have an impact on energy cost and use. In North Carolina, the Public Utilities Commission in

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[1]Carolina Power and Light Company, Rate Schedules, (Raleigh, N.C.: Carolina Power and Light Company, 1 July 1979).

setting electric and natural gas rates impacts school costs and causes schools to be eligible or ineligible for certain rates.

School electric rates will be covered as an example of the type of regulation promulgated by the Utilities Commission. Duke Power Company, the largest electrical supplier in the state, will be used as the example for school rates.

Duke has a number of rate schedules, but those rates available to particular schools depend on load characteristics. Some rates, residential, industrial, and resale, are not available to schools. Within the classification system used by Duke Power, all school rates are classified as General Service. General Service schedules are subdivided depending on the type of heating and cooling equipment used, for example general service, water heating; general service, all electric; general service, all electric/solar (experimental); general service, miscellaneous.[1]

Rate structures are hard to understand and when the concepts of contract demand and demand billing are added, many school people simply are not informed. By far, the best way to learn of particular rates is to contact the appropriate energy company and request an explanation. In the following section, one particular general service rate schedule - general service, all-electric - will be examined. The general understanding of this schedule should make it easier for the school administrator to comprehend the particular schedule for his/her jurisdiction. Since rate schedules vary from company to company, from time to time, and from state to state, the schedule which is being used as an example is the one applicable for Duke Power's North Carolina customers as of 1 January 1982.

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[1]Duke Power Company, Rate Schedules, (Charlotte, N.C.: Duke Power Company, 1 Jan. 1982), passim.

Examination of the rate schedule for general service, all-electric-designated GA (NC) - reveals several sections. These sections are availability, types of service, rate, approved fuel charge, determination of billing demand, minimum bill, power factor correction, payment, contract period, and interruptible power provisions.[1]

To understand fully the make-up of the school or school system electric charges, it is necessary to understand each of these sections. A school administrator may have a difficult time understanding all the terms used in the various sections. If the school system is large enough, a specialist can be hired to provide the constant monitoring needed to reduce not only energy consumption but energy costs.

Explanations of the sections from the schedule on availability, type of service, and rate are sufficient within the Duke electric rate schedule itself. The approved fuel charge for general service customers is figured on the same basis as for residential customers. Namely, if cost for fuel rises or falls from the amount allowed in the base rates, then a fuel charge adjustment will be made.

Schools, as well as other general service customers, are billed for electric energy that the electric utility supplies to them. In addition to the cost for the total amount of electricity, large users are also charged for the greatest demand over a 15-minute period. Demand charges accrue due to the fact that the electric company must size its generators, substations, transformers, transmission lines, and meters based upon the volume of electricity required. For example, if an individual were to require one kilowatt of electricity each hour for twenty-four hours, the total electricity used would be twenty-four kilowatt-hours (24 kwh). If, on the

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[1]Ibid., N.C. 28th Revised Leaf no. 22, pp. 1-4.

other hand, a consumer were to use twenty-four kilowatts of electricity for one hour the total use would likewise be 24 kwh. From the company's standpoint, the two usages described create entirely different problems. The total number of kilowatt hours used is identical in the two examples; it is the rate of use which varies. An attempt by the Utilities Commission to achieve equity among ratepayers dictates Duke Power's requirement of a demand charge based on the rate of demand. This demand affects rates; it is also important in determining the minimum bill.

Demand, sometimes called billing demand, may be considered important only for a particular month. This assumption is not entirely accurate, as an examination of the wording from the appropriate section of the rate schedule will illustrate.

> The demand for billing purposes each month shall be the maximum integrated thrity-minute demand measured during the month for which the bill is rendered, but not less than 50 percent of the maximum monthly demand during the previous 12 months, including the month for which the bill is rendered, nor less than 50 percent of the contract demand, nor less than 15 kw; however, the minimum billing demand for contracts made prior to March 15, 1971 shall be 5 kw until the maximum integrated thirty-minute demand measured during the month for which the bill is rendered becomes 15 kw or more, after which time the minimum billing demand on such contracts shall be 15 kw.[1]

When the statement on billing demand is analyzed, it becomes clear that not only does a high demand affect the rate in a particular month, but also this demand charge is also billed for the following twelve months. This process is referred to as the twelve-month ratchet.

Figure 11 contains data illustrating the fact that billing kw demand does not always match actual kw demand. In the illustration, the two demand figures are the same during the months of November-February. However, in March actual demand was 102 kw while billing kw was still 117 kw as it had

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[1]Ibid., p. 2.

been the previous month. This discrepancy continues into April and May where the actual demands were 62 kw and 16 kw respectively and the billing demand remained at 117 kw. This illustrates what is meant by the twelve-month ratchet. During any consecutive twelve month period, the billing demand will be the highest actual demand which occurs during that twelve months. In the example illustrated by figure 11, the 117 kw billing demand will be the demand charge for the twelve months following February, 1982 unless a higher demand were to occur during the period. If a higher demand occurs, then it is the billing demand for twelve months or until another higher demand occurs.

MONTH	KWH	ACTUAL KW DEMAND	CONTRACT KW DEMAND	BILLING KW DEMAND	BILL AMOUNT
Nov 81	12920	76	5	76	$614.65
Dec 81	9400	90	5	90	575.24
Jan 82	7960	99	5	99	528.20
Feb 82	14280	117	5	117	786.70
Mar 82	9440	102	5	117	619.47
Apr 82	1960	62	5	117	333.69
May 82	920	16	5	117	262.93

Fig. 11. Six month billing history for Newell Elementary School (1981-82)[1]

If a contract demand is set too high, at least 50% of that demand will be charged regardless of use. Large school systems having consultants and those using the state education agency consultants should have no trouble in accurately determining an appropriate demand. Systems which have novice contractors and who fail to utilize advice from the state agency and the

[1]Duke Power Company, Retail Department, Computerized Customer Billing, 3 May 1982

utility company may be penalized by higher electric bills than are necessary.[1]

Future Options

If the morass of governmental regulations, laws, rate structures, and procedures are incomprehensible, the future options for the school administrator are difficult.

An attempt to discuss the long-term energy future would, upon examination, be found to be the energy present in one school system or another. Some systems have managers more attuned to change who make those futuristic steps before the majority of the other administrators.

New developments in the energy field, as noted earlier, are happening at a very rapid pace. These developments include, not only new inventions and discoveries, but also new ways of looking at old problems. Some of the new ideas possibly can be utilized by schools, others will have limited application at best.

Courses in energy basics should be considered important by all prospective school administrators. For those superintendents and principals already on the job, a series of workshops to fill the knowledge gap should be a primary goal of state boards of education and schools and departments of education in the universities.

Failure to take full advantage of energy saving technology hurts everyone, but may ultimately precipitate a crisis, as far as the educational system is concerned.

Because there is a lot of effort being expended by the various governmental agencies to legislate or regulate energy issues, it is

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[1]Ibid., pp. 3-4.

necessary for school administrators to have some local method of assessing the myriad claims of energy savings which are being made. Many of these local efforts can be carried out by the energy officers in the system, if the system is large enough to be able to afford such an officer. In many cases, the system cannot afford such an officer. This situation is the ideal application for the computer program entitled SCHOOL RETROFIT DESIGN ANALYSIS SYSTEM (SRDAS).

Having an energy assessment done can be expensive and in some cases not worth the cost in terms of energy saved.[1] If there are qualified engineers on the system's staff, a series of ten programs being developed at the University of Texas for the Apple II microcomputer provides energy management calculations. The programs will retail for $45 each. The first three programs were available in 1981 and are entitled "Properties of Steam," "General Heat Loss Calculations," and "General Curve Fitting."[2] While these programs are good, they are not easily useable by a lay person.

Some states can provide assistance to the local education agencies in the area of energy determinations and may charge for these services. Generally, the cost in these cases is not the problem, but the time required for the assessment to be given to the local system. SRDAS is something that the local system can have available for a general assessment of any particular energy upgrade that might be suggested. It should be understood that this system gives only a general understanding of the costs and payback involved through additions. The key to its use is that it enables the administrator to decide whether something is deserving of an in-depth

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[1]James E. Piper, "The Energy Audit: What It Can Do for You," American School and University 50 (March 1978): 58.

[2]"University Marketing 3 Software Programs," Energy Users News, 2 November 1981, p. 13.

engineering analysis. In other words, SRDAS is like a preliminary analysis for a proposed project.

CHAPTER IV

USE OF THE PROGRAM

The use of the administrative modeling program (SRDAS) will be simple for the computer professional as well as for the computer novice. Making programs easy to use is termed user-friendly. This program is user-friendly because each request for information is presented in such a way that the person using the program can respond by simply typing a "Y" for yes, "N" for no, or a number from a list which is presented on the video screen. A program having this type of choice is termed a menu-driven program. The list of the options is called a menu.

Once a program is entered into the computer, either by typing it or by the computer using a magnetic storage medium, it is said to be loaded into the computer's memory. Appendix B is a written form of the complete program with all its subparts. The entire program has been written in a computer language called basic. This language is standard for the Apple II microcomputer on which the developmental work was done. It is possible to use the program on any computer which has the capability to understand the basic commands. If the person who desires to use this program does not have a computer with the ability to store and then load subprograms separately from either magnetic tape or disk, use of the program will be severely restricted because each subprogram will have to be entered manually. If the user enters the program from the appendix it will be necessary to type each subprogram separately and then to save that part onto whatever storage

medium the user's machine has. The ideal medium for this application is a magnetic disc storage. Any user with magnetic disc capabilities and using an Apple II computer may obtain a copy of the program from the author. This copy can be used immediately without the need to type the program into the computer. A program which is stored on magnetic tape is termed a machine-readable program because the computer can "read" the information which has been coded electronically onto the tape.

The rest of this chapter is devoted to a step by step description of what a user will see once the program has been entered into a computer and is running. Running the various subprograms and selecting from the options presented in the menus are facilitated by the display of information on the video screen. Each time new information is presented to the user on the screen, some response from the user is required for the program to continue. Giving the proper instruction to the computer will continue the program and allow the presentation of another screen of information for the user. These screens are presented in this chapter so that the user can become aware of the types of information required in each part of the overall program.

The introductory subprogram simply loads the title onto the screen and then asks the user to press any key to continue the exercise. Once a key is pressed another subprogram--the MENU--is loaded into the computer's memory. This subprogram lists the various options available to the user at this particular time. The options are:

1. BTU/SQ. FT.
2. BUILDING ANALYSIS
3. PAYBACK
4. END.

If the END subprogram is selected, the user leaves the series of subprograms completely and must restart the introductory subprogram to continue. Any other selection will load additional programming into the computer's memory and begin a series of questions to find the current situation with respect to the particular area chosen. The information that is entered by the user is processed by arithmetic programs residing in the computer memory. An answer is presented on the video display or on paper if a printer is being used.

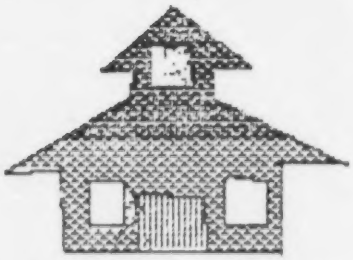
Certain conditions are assumed within each of the parts. These assumptions are given at the beginning of each of the subprograms. In some cases, the user is asked to change some of the data depending on the local situation. An example of this is in the BTU/SQ. FT. program where the user must enter applicable electricity costs for the local utility.

A sample run conducted for Newell Elementary School in the Charlotte-Mecklenburg School System using this program is presented in the appendix.

All options of this program will be explained along with potential problems which the user might face. The remainder of this chapter will describe each video screen and explain what is being requested at each step. Having the program loaded into a computer will greatly facilitate the user's ability to comprehend the information presented in this chapter. Consulting the sample run will enable the user to see the relationships between data entered into the program and information obtained from the program.

Whenever the first screen appears there is an instruction to HIT ANY KEY TO CONTINUE. Striking any key on the keyboard will cause the next subprogram--PRIMARY MENU-- to be loaded and display the intention of this subprogram along with other developmental information. Again there is the

School
Retrofit
Design
Analysis
System



System designed by
STEPHEN CANIPE
Charlotte, NC
704/373-4530

instruction HIT AND KEY TO CONTINUE. These two screens are shown in figures 12 and 13.

HIT ANY KEY TO CONTINUE

Fig. 12. Title screen shown when program is loaded into computer memory

THIS PROGRAM IS DESIGNED TO HELP SCHOOL ADMINISTRATORS DETERMINE THE ENERGY USE, NEEDED ENERGY IMPROVEMENTS, AND PAYBACK PERIODS FOR THEIR SCHOOLS.

PREPARED BY STEPHEN L CANIPE

DECEMBER, 1981

HIT ANY KEY TO CONTINUE

Fig. 13. Introductory screen for SRDAS

When a key is struck while figure 13 is displayed the computer will display a menu for selecting the particular subprogram desired. The MENU is

shown in figure 14. There are four options available to the user at this point, any of which can be chosen by hitting the appropriate key as indicated.

If key 1 (BUILDING ANALYSIS) is selected, this subprogram is loaded from the disk. First, an informational screen will appear giving some basic information about this subprogram. Figure 15 shows this screen. There is the HIT ANY KEY TO CONTINUE instruction as the final line on this screen.

MENU

CHOOSE FROM THE MENU THE OPERATION THAT YOU WOULD LIKE TO SEE.

SELECT BY THE NUMBER, PLEASE!

1. BUILDING ANALYSIS
2. BTU/SQ. FT.
3. FIGURE PAYBACK PERIOD
4. END

Fig. 14. Primary menu from School Retrofit Design Analysis System

B U I L D I N G A N A L Y S I S

THIS PROGRAM WILL EXAMINE VARIOUS
ASPECTS OF SCHOOL HOUSE DESIGN AND WILL
DETERMINE THE BTU LOSS (OR GAIN) FROM
FROM THE VARIOUS COMPONENTS

THE MENU BELOW WILL ENABLE YOU TO SELECT ANY SPECIFIC COMPONENT OR ALL OF THEM.

HIT ANY KEY TO CONTINUE

Fig. 15. Introductory screen for Building Analysis subprogram

Figure 16 shows the options which are available from this particular point. The user can select any one of the six options listed. Choosing any one will take the user to that particular part of the program. When a particular part is finished the program will return the user to the menu shown in figure 15. Only by selecting option 6 will the program return to the PRIMARY MENU shown in figure 14. In other words, each of the five components of building design can be evaluated within this subprogram.

MENU

1. ROOF
2. FLOORS
3. INFILTRATION
4. WALLS
5. WINDOWS
6. END

SELECT OPTION BY NUMBER

Figure 16. Menu screen from BUILDING ANALYSIS subprogram.

Data sheets for the user are provided in the appendix. These data sheets have some information which should be collected prior to beginning the analysis. There are spaces on the sheets to record the computer calculated information which is presented to the user during the program execution.

If BTU/SQ. FT. is selected from the PRIMARY MENU (option 2), the user will see the screen presented in figure 17. This is an informational screen and the user must hit another key to see the menu for this section.

Hitting a key will display the menu for this subprograms. Figure 18 shows the selections available to the user. Any of the five options can be selected simply by pressing the appropriately numbered key.

BTU PER SQUARE FOOT

THIS PROGRAM IS DESIGNED FOR THE SCHOOL ADMINISTRATOR WHO WANTS TO BECOME MORE FAMILIAR WITH THE USE OF THE COMPUTER IN MANAGING THE FACILITIES AND IN UNDER-STANDING THE BUDGET COSTS ASSOCIATED WITH ENGERY USE.

USE OF THIS PROGRAM WILL NOT MAKE YOU AN EXPERT, BUT WILL ENABLE YOU TO MAKE COMPUTER-ASSISTED DECISIONS. THERE WILL BE A MENU PRESENTED FOR YOU TO SELECT THE TOPIC THAT YOU WISH TO EXPLORE. ALL YOU NEED TO DO IS TO PRESS THE PROPER NUMBER FOR THAT PART OF THE PROGRAM TO EXECUTE.

HIT ANY KEY TO SEE MENU

Fig. 17. Introductory screen from BTU/SQ. FT. subprogram

Selecting option 5 will return the user to the PRIMARY MENU, any other choice will display an informational screen and request user input of information. The data sheet for this section has spaces for the information which should be collected prior to beginning this series of subprograms. It also has the blanks for recording the results of the calculations which the computer will perform. Through this method, the user can try alternate scenarios to determine the impact of each.

After each subprogram is completed, the user will be returned to the menu and asked if there are additional Btu calculations which need to be

performed. Selection of option 5 will return the user to the PRIMARY MENU. It is only from the PRIMARY MENU that SRDAS can be ended.

MENU

1. PERCENT INSTRUCTIONAL USE SPACE
2. TOTAL DAILY STUDENT COSTS
3. ENERGY COSTS
4. BTU PER SQUARE FOOT
5. END

PRESS THE NUMBER OF THE ROUTINE NEEDED

Fig. 18. Menu screen from BTU/SQ. FT. subprogram

From the PRIMARY MENU, option 1 (BUILDING ANALYSIS) will be selected and each of the possibilities in this subprogram will be explored. The screens showing the menus are displayed in figures 14 and 16.

When option 1 is selected, an informational screen is presented (shown in figure 19). This screen gives instructions on how questions are to be answered. Any key is hit to continue the program.

THIS PART OF THE PROGRAM WILL ASK YOU SEVERAL QUESTIONS ABOUT THE ROOF ON THE BUILDING(S) IN QUESTION.

YOU SHOULD RESPOND WITH (Y) OR (N) TO EACH QUESTION. IN THE EVENT YOU HAVE ADDED ADDITIONAL INSULATING MATERIALS YOU WILL BE REQUIRED TO TYPE IN THE CORRECT VALUE FROM THE TABLE WHICH WILL APPEAR ON THE SCREEN.

HIT ANY KEY TO CONINUE....

Fig. 19. Introductory screen in Roof subprogram

A series of questions are then asked to determine the roof type and area. In addition, the formula used to calculate heat loss is presented and explained. These screens are shown in figures 20-22. The user is asked if there have been additional materials added to the roof or if proposed additions are to be considered. These questions allow the user to custom-tailor the program to a particular situation.

```
DO YOU HAVE A FLAT-BUILT-UP ROOF? (Y/N)  XXXX

     THE CALCULATIONS DONE IN THIS SECTION
     ARE BASED ON THE FORMULA:


                    Q/A=UΔT

     WHERE Q= HEAT TRANSFER; A= AREA;
     U=HEAT TRANSFER COEFFICIENT; AND ΔT=
     CHANGE IN TEMPERATURE.

     THE DESIGN TEMPERATURE USED IS 18 DEG-F
     AT THE WINTER CONDITIONS AND 93 DEG-F
     AT THE SUMMER CONDITIONS.

     SINCE THE WINTER CONDITIONS ARE MOST
     SEVERE THEY WILL SERVE AS THE BASIS FOR
     CALCULATIONS.

           HIT ANY KEY TO CONTINUE
```

Fig. 20. Information screen from Roof subprogram

```
DO YOU HAVE A PITCHED ROOF? (Y/N)  XXXX

     PITCHED OR SLOPED ROOFS HAVE BEEN MAKING
     A COME-BACK IN RECENT YEARS.  MOST OF
     THE INSULATING MATERIALS WHICH CAN BE
     USED ARE FOUND IN THE CHART BELOW.  ALL
     THAT YOU HAVE TO DO IS TO ADD THE R-
     VALUES FROM THE FOLLOWING TABLE THAT
     YOU HAVE ADDED OR WISH TO ADD TO YOUR
     ROOF.
```

HIT ANY KEY TO CONTINUE

Fig. 21. Information gathering screen from Roof subprogram

I N S U L A T I N G M A T E R I A L S

A. BATT/BLANKET=3.14 R/INCH
B. EXPANDED POLYSTYRENE=4.5 R/INCH
C. CELLULAR POLYURETHANE=6.25 R/INCH
D. POLISOCYANURATE=7.2 R/INCH
E. LOOSE MINERAL FIBER=2.2 R/INCH

NUMBERS ARE APPROXIMATE

CONSULT THE VENDOR FOR EXACT R-VALUES

HIT ANY KEY TO CONTINUE

WHAT ARE THE DIMENSIONS OF YOUR ROOF
XXXXXX. IF THERE HAS BEEN NO ADDITIONAL
INSULATION ADDED THE HEAT LOSS EQUALS
XXXX BTU/HR.

ENTER THE TOTAL R-VALUE OF MATERIALS
FROM THE TABLE ABOVE.

THE HEAT LOSS WITH THIS INSULATION IS
XXXX BTU/HR. THIS IS A SAVINGS OF
XXXX BTU/HR.

HIT ANY KEY

Fig. 22. Summary screen for Roof subprogram

When the roof questions have been asked and answered and the data have been recorded on the data sheet, the user is returned to the BUILDING ANALYSIS MENU. If the option FLOORS is selected, there will be an informational screen like figure 23 displayed. Hitting any key will begin the information gathering by the program. Questions about the type of floor, whether it is a slab-on-grade or a crawl space type will be asked. Figures 24 and 25 show the basic questions to determine floor type, size of

school, and current flooring. The next screen (figure 26) shows the formula which will be used and offers several common types of floor additions.

```
THIS PART OF THE PROGRAM WILL ASK YOU
SEVERAL QUESTIONS ABOUT THE FLOOR IN
THE BUILDING(S) IN QUESTION.

YOU SHOULD RESPOND WITH (Y) OR (N) TO
EACH QUESTION.  IN THE EVENT YOU HAVE
ADDED ADDITIONAL INSULATING MATERIALS
YOU WILL BE REQUIRED TO ENTER THE
CORRECT VALUE FROM THE TABLE WHICH WILL
APPEAR ON THE SCREEN.

        HIT ANY KEY TO CONTINUE...
```

Fig. 23. Introductory screen from Floor subprogram

```
DO YOU HAVE A SLAB-ON-GRADE FLOOR?
(Y) OR (N) XXX
YOU HAVE NO APPRECIABLE HEAT LOSS.
THROUGH THE FLOOR.  FOR THE PURPOSE OF
THIS ANALYSIS YOU MAY CONSIDER THE LOSS
EQUAL TO 0 BTU/HR.

        HIT ANY KEY TO CONTINUE
```

Fig. 24. Information gathering screen from Floor subprogram

```
DO YOU HAVE A SLAB-ON-GRADE FLOOR?
(Y) OR (N)   XXX
THE ANALYSIS FOR THE FLOOR IS BASED UPON
THE FOLLOWING BASIC MATERIALS, IF YOUR
CONSTRUCTION HAS ADDITIONAL MATERIALS
YOU WILL NEED TO ADD THEM FROM THE
TABLE OF VALUES WHICH WILL BE PRESENTED.

THE TYPICAL FLOOR HAS A 3 INCH CONCRETE
SLAB ON METAL BEAMS; AND TILE.  THE FORMULA
USED IS AS FOLLOW:

              Q=UAΔT

WHAT ARE THE DIMENSIONS OF YOUR BUILDING?
?XXXXXX
THE HEAT LOSS FROM YOUR FLOOR IS XXXXX
BTU/HR. HAVE YOU ADDED ADDITIONAL MATERIALS
```

```
TO YOUR FLOORS OR WISH TO SEE Q-VALUES
FROM PROPOSED ADDITIONS? (Y) OR (N)   XXX
```

Fig. 25. Informational screen from Floor subprogram

```
    CARPET & FIBROUS PAD--2.08
    CARPET & RUBBER PAD--1.23
    TERRAZZO--.08
    HARDWOOD FINISH--.68
    BATT/BLANKET--3.14 R/IN

WHAT IS THE TOTAL ADDITIONAL R-VALUE?
?XXXXXX

THE HEAT LOSS WITH THIS AMOUNT OF INSUL-
ATING MATERIAL IS XXXXX BTU/HR.
THIS IS A SAVINGS OF XXXXX BTU/HR.
```

Fig. 26. Summary screen from Floor subprogram

The user is requested to answer what the R-value of the material added or proposed is. Once this information is entered, the computer performs the analysis of what the heat loss without the addition and with the addition will be and gives the difference in Btu/hr loss.

The user is once more returned to the BUILDING ANALYSIS MENU for additional calculations. If option 3 (INFILTRATION) is selected, the first screen displayed is shown in figure 27. This is an informational screen and instructs the user to continue by hitting any key.

```
THIS PART OF THE PROGRAM WILL ASK YOU
SEVERAL QUESTIONS ABOUT INFILTRATION IN
THE BUILDING(S) IN QUESTION.

YOU SHOULD RESPOND WITH (Y) OR (N) TO
QUESTIONS OR BY ENTERING NUMBERS AS
REQUESTED.

        HIT ANY KEY TO CONTINUE..
```

Fig. 27. Introductory screen from Infiltration subprogram

Screens shown next are informational gathering screens. Questions asked are type of wall, fit of windows, and perimeter of windows. These screens are shown in figures 28-31. Finally a question is presented to determine if there have been additional materials added or proposed to be added to the basic wall and windows from an infiltration standpoint. This screen is shown in figure 32.

Many different combinations of actions can be evaluated in this series of subprograms by answering the question shown in figure 32 positively. Whenever there is a negative response, the program will recycle the user to the BUILDING ANALYSIS MENU.

```
IN ORDER TO FIGURE INFILTRATION IT IS
NECESSARY TO HAVE VALUES FOR WALL
SQUARE FOOTAGE AND WINDOW PERIMETERS.
IT WILL BE NECESSARY TO MAKE SOME
ASSUMPTIONS ABOUT THE VENTILATING AIR
AND BUILDING PRESSURIZATION.
DO YOU HAVE BRICK WALLS ?   XXX
DO YOU HAVE WOOD FRAME WALLS ?   XXX
WHAT IS THE AREA OF THE WALL (SQ. FT.)
XXX FROM THE FOLLOWING SELECT THE ONE
WHICH BEST DESCRIBES YOUR WINDOWS:

1.   LOOSE FITTING WITH OR WITHOUT
     WEATHERSTRIPPING
2.   AVERAGE FIT WITH WEATHERSTRIPPING
3.   AVERAGE FIT WITHOUT WEATHERSTRIPPING
ENTER THE NUMBER   XXX
```

Fig. 28. Information gathering screen from Infiltration subprogram

```
WHAT IS THE TOTAL PERIMETER IN FEET OF
ALL WINDOWS
?XXXX
SELECT HOW YOUR WINDOWS ARE SET FROM
THE FOLLOWING MENU:
1.   MASONERY WALL, NOT CAULKED
2.   MASONERY WALL, CAULKED
3.   FRAME WALL, CAULKED OR NOT
ENTER NUMBER   XXX
```

Fig. 29. Information gathering screen from Infiltration subprogram

```
THE INFILTRATION CALCULATIONS ARE BASED
ON THE FOLLOWING FORMULA

                Q=MCΔT

WHERE Q= HEAT LOSS IN BTU/HR; M=MASS OF
AIR; C=SPECIFIC HEAT; AND ΔT=CHANGE IN
TEMPERATURE


        HIT ANY KEY TO CONTINUE
```

Fig. 30. Information screen from Infiltration subprogram

```
THE TOTAL HEAT LOSS DUE TO INFILTRATION
IS XXXX BTU/HR.


        HIT ANY KEY TO CONTINUE
```

Fig. 31. Summary screen from Infiltration subprogram

```
HAS THERE BEEN ADDITIONAL INSULATING
MATERIAL ADDED OR DO YOU WISH TO
CONSIDER THE ADDITION?   XXX
FROM THE FOLLOWING SELECT THE ONE
WHICH BEST DESCRIBES YOUR WINDOWS:
1.   LOOSE FITTING WITH OR WITHOUT
     WEATHERSTRIPPING
2.   AVERAGE FIT WITH WEATHERSTRIPPING
3.   AVERAGE FIT WITHOUT WEATHERSTRIPPING
ENTER THE NUMBER XXX
WHAT IS THE TOTAL PERIMETER IN FEET OF
ALL WINDOWS?
?XXXX
SELECT HOW YOUR WINDOWS ARE SET FROM
THE FOLLOWING MENU:
1.   MASONERY WALL, NOT CAULKED
2.   MASONERY WALL, CAULKED
3.   FRAME WALL, CAULKED OR NOT
ENTER THE NUMBER XXX
```

Fig. 32. Informational gathering screen from Infiltration subprogram.

When option 4 is selected from the menu there is an informational screen dealing with the walls of the building presented. This is shown in figure 33. The next screen which is displayed is also an informational one. It describes the formula which is used to calculate heat loss and describes the "basic" wall. Figure 34 shows this screen.

```
THIS PART OF THE PROGRAM WILL ASK YOU
SEVERAL QUESTIONS ABOUT THE WALLS IN
THE BUILDING(S) IN QUESTION.
YOU SHOULD RESPOND WITH (Y) OR (N) TO
EACH QUESTION.  IN THE EVENT YOU HAVE
ADDED ADDITIONAL INSULATING MATERIALS
YOU WILL BE REQUIRED TO ENTER THE
CORRECT VALUE FROM THE TABLE WHICH WILL
APPEAR ON THE SCREEN.

          HIT ANY KEY TO CONTINUE...
```

Fig. 33. Introductory screen from Wall subprogram

```
THE ANALYSIS IS BASED UPON THE FOLLOWING
ASSUMPTIONS AS FAR AS THE BASIC
CONSTRUCTION IS CONCERNED.  IF YOU HAVE
ADDED OR PLAN TO ADD MATERIALS ABOVE THE
BASIC WALL, YOU MUST ENTER THE R-VALUE
FOR THESE ADDITIONS WHEN ASKED TO DO SO.

THE BASIC WALL IS COMPOSED OF A 4 IN.
COMMON BRICK; A NONREFLECTIVE AIR SPACE;
AND A 4 IN. CINDER AGGREGATE BLOCK

THE FORMULA USED FOR THIS CALCULATION
IS
                Q=UAΔT

          HIT ANY KEY TO CONTINUE
```

Fig. 34. Basic wall calculation screen from Wall subprogram

The next two screens (figures 35-36) present and gather information. They display questions about the size of the wall area and its type of insulation/construction. A list of additional insulating materials is presented and the user is requested to enter the total R-value of added or proposed materials. When the user has entered the value, the computer program will analyze the additions and compare the R-value before and after. The difference in Btu/hr will be presented to the user.

```
PLEASE ENTER THE TOTAL SQUARE FOOTAGE
OF YOUR WALLS MINUS THE WINDOW AREA
XXXX
IF YOU HAVE THE BASIC WALL THE HEAT LOSS
IS EQUAL TO XXXX BTU/HR

HIT ANY KEY TO CONTINUE
```

Fig. 35. Informational screen from Wall subprogram

```
HAVE YOU ADDED OR WOULD YOU LIKE TO KNOW
THE EFFECT OF ADDING ADDITIONAL INSUL-
ATING MATERIALS?  (Y) OR (N) XXXX
  REFLECTIVE AIR SPACE--1.75

  FILLED BLOCK CORES--1.5

  .5 IN GYPSUM WALL BOARD--.45

  POLYURETHANE FOAM--5.88

  UREAFORMALDEHYDE FOAM--4.0

  CELLULOSIC FIBER SPARY--3.7

  PERLITE OR VERMICULITE SPRAY--1.67

ENTER THE TOTAL ADDITIONAL R-VALUE FROM
THE TABLE OR FROM VENDORS OF UNLISTED
MATERIALS TO GET A TOTAL WALL HEAT LOSS
XXXX
THE ADDITIONAL INSULATION YIELDS A HEAT
LOSS OF XXXX BTU/HR.
THIS IS A DIFFERENCE OF XXXX BTU/HR.
```

Fig. 36. Informational screen from Wall subprogram

When the differences have been recorded on the data sheet the user hits any key to continue. This returns the user to the menu for this section. If option 5 is selected, the first screen to appear is an informational screen concerning the windows in the building. Figure 37 shows this screen.

```
THIS PART OF THE PROGRAM WILL ASK YOU
SEVERAL QUESTIONS ABOUT THE WINDOWS IN
THE BUILDING(S) IN QUESTION.
YOU SHOULD RESPOND WITH (Y) OR (N) TO
EACH QUESTION.  THERE WILL BE A CHANCE
TO FIND OUT THE EFFECT OF UPGRADING
WINDOWS IN YOUR BUILDING.

HIT ANY KEY TO CONTINUE...
```

Fig. 37. Introductory screen in Window subprogram

The next screen is both information giving and requesting. The user is requested to input the total square footage of windows facing in several directions. After entering each of the numbers, the user must also hit the RETURN key so that the computer will know the input is complete. Figure 38 shows the appearance of this screen. When all the data concerning window orientation have been entered, the screen clears and the question concerning the type of window is presented. By responding with a "Y" or an "N" the appropriate values are selected from the computer memory to analyze the heat loss. This screen is shown in figure 39. Figure 39 also shows that the formula used to calculate the loss is presented to the user. When the user wishes to continue, a key is hit. This moves the program to a summary step and the heat loss per hour is presented. Figure 40 shows this screen.

```
IN KEEPING WITH OUR CONVENTION OF USING
WINTER DESIGN CONDITIONS, ALL DATA WILL BE
FOR WINTER DESIGN CONDITIONS.
IT WILL BE NECESSARY FOR YOU TO SUPPLY
CERTAIN INFORMATION ABOUT THE AREA OF
GLASS FACING IN VARIOUS DIRECTIONS.
TYPE IN THE AREAS AS REQUESTED, THEN

        HIT THE (RETURN) KEY

WHAT IS THE WINDOW AREA FACING NORTH?
XXXX
WHAT IS THE AREA FACING NORTHEAST?
? XXXX
WHAT IS THE AREA FACING EAST ?
? XXXX
WHAT IS THE AREA FACING SOUTHEAST?
? XXXX
WHAT IS THE AREA FACING SOUTH?
? XXXX
WHAT IS AREA FACING SOUTHWEST?
? XXXX
WHAT IS THE AREA FACING WEST?
XXXX
WHAT IS THE AREA FACING NORTHWEST?
XXXX
```

Fig. 38. Informational gathering screen in Window subprogram

```
YOU WILL NEED TO SUPPLY ONE OTHER BIT
OF DATA CONCERNING YOUR WINDOWS.
ARE YOU WINDOWS OF SINGLE GLASS
CONSTRUCTION ?   XXX
THE HEAT COEFFICIENT FORMULA WHICH WILL
BE USED WILL BE

        Q=UAΔT

WINTER DESIGN CONDITIONS WILL BE USED.

        HIT ANY KEY TO CONTINUE
```

Fig. 39. Informational screen from Window subprogram

HEAT LOSS FROM YOUR SINGLE GLAZED WINDOW
IS EQUAL TO XXXX BTU/HR.

HIT ANY KEY TO CONTINUE

Fig. 40. Informational screen from Window subprogram

If the user has plans for upgrading the windows, this intention can be examined by the computer program. By entering the appropriate information in response to the prompts, the user can determine what the addition of storm windows or double paned windows can have on the heat loss in the building. Figure 41 shows this screen.

WOULD YOU LIKE TO SEE THE LOSS IF YOU
UPGRADE YOUR WINDOWS? . XXX
DO YOU HAVE STORM WINDOWS ? XXX
THE HEAT COEFFICIENT FORMULA WHICH WILL
BE USED WILL BE

$Q=UA\Delta T$

WINTER DESIGN CONDITIONS WILL BE USED.

HIT ANY KEY TO CONTINUE

HEAT LOSS FROM YOUR STORM SASHED WINDOWS
IS EQUAL TO XXXX BTU/HR.

Fig. 41. Informational screen in Window subprogram

After the upgrade has been considered, the computer will move on to the other important aspect concerning windows -- radiant heat gain. The month chosen for analysis is December since it has the lowest amount of solar heat gain. The site used is one at the same latitude as Durham, North Carolina (36-degree N). The window direction and area that were entered earlier form

the basis for this calculation. The total solar heat gain is presented to the user. Subtracted from the total is the heat loss due to conduction through the glass. The heat gain presented is the maximum amount possible. There is an assumption of no shading either internally or externally. Figure 42 shows the final screen in the window section.

```
WOULD YOU LIKE TO SEE THE LOSS IF YOU
UPGRADE YOUR WINDOWS? XXX
DECEMBER IS THE MONTH CHOSEN FOR THE
CALCULATIONS SINCE THIS IS THE LEAST
SOLAR HEAT GAIN MONTH.
DATA ASSUME SUNNY DAYS.  IF THERE IS
CLOUD COVER ASSUME NO HEAT GAIN.
THE DESIGN LATITUDE IS 36 DEG NORTH.
THE TOTAL SOLAR HEAT GAIN FOR THE MONTH
OF DECEMBER IS EQUAL TO XXXX BTU/HR.
```

Fig. 42. Summary screen for Window subprogram

When a key is hit, the program returns to the menu for BUILDING ANALYSIS. Since all of the program options have been completed, option 5--END--is selected. This choice returns the user to the PRIMARY MENU (figure 14). At this point the user may select another subprogram such as BTU/SQ.FT., PAYBACK, OR END which would exit SRDAS.

If BTU/SQ. FT. is selected, an informational screen is presented. Any key will present the MENU for the subprograms in this section. Figures 17 and 18 display these screens.

If the first option is chosen, the screen presented will look like the one in figure 43. The program requests two inputs--the total number of square feet in the building and the area for which the percent of instructional use space is to be figured. The answer is returned as a whole number with the notation that it is in percent.

THIS ROUTINE FIGURES THE PERCENT OF
SPACE DEVOTED TO INSTRUCTIONAL USES. IF
YOU ALREADY KNOW THIS FIGURE TYPE 'Y' TO
RETURN TO THE MENU, OTHERWISE HIT RETURN
TO CONTINUE XXX
YOU CAN USE THIS PROGRAM FOR THE ENTIRE
SCHOOL OR FOR PARTICULAR CLASSROOMS.

WHAT IS THE AREA OF THE FACILITY
(IN SQUARE FEET)?
ENTER THE NUMBER, THEN TYPE RETURN XXXX

HOW MANY SQUARE FEET ARE DEVOTED TO IN-
STRUCTIONAL PURPOSES? ENTER THE NUMBER
THEN HIT RETURN XXXX

THE PERCENT OF INSTRUCTIONAL USE SPACE
IS XXXX

Fig. 43. Screen showing Percent Instructional Use Space

Hitting any key returns the user to the menu for this section. Selecting option 2--TOTAL DAILY STUDENT COSTS--requires the user to have the data shown in figure 44. When these data are entered into the computer memory in the requested sequence, the computer first displays the instructional costs, then the non-instructional costs, and finally the total costs per pupil per day. The analysis can be done for a particular class to determine the cost of a subject or for the school as a whole. The use for individual classes will enable the administrator to gain an insight into the cost of particular classes. Figures 45-48 display the information just described. Hitting any key returns the user to the section menu.

The following formulas are utilized in arriving at the cost figures:

1) $$\frac{\frac{CA}{TNT} + \frac{SSC}{TIS} + ATC}{NP \times SD} = \frac{\text{Cost/hr.}}{SIC}$$

CA = central administrative costs; TNT = total number of teachers; SSC = school service costs; TIS = teachers in the school; ATC = average teacher cost salary; NP = number of periods teacher teaches; SD = number of school days; SIC = students in the class.

2) $$\frac{\frac{TC}{TNS}}{SP \times SD} + \frac{\frac{OM}{TNS} \times SIS \times \%IUS}{SP \times SD \times SIC} = \text{cost/hr.}$$

TC = transportation costs; TNS = total number of students; SP = number of student periods; SD = number of school days; OM = operation and maintenance costs; SIS = students in schools; %IUS = percent of instructional use space.[1]

IN ORDER TO FIGURE COSTS ON A STUDENT BASIS IT IS NECESSARY FOR YOU TO HAVE THE FOLLOWING DATA.

1. CENTRAL ADMINISTRATIVE COSTS
2. TOTAL NUMBER OF TEACHERS
3. SCHOOL SERVICE COSTS
4. AVERAGE TEACHER COST SALARY
5. TRANSPORTATION COSTS
6. TOTAL NUMBER OF STUDENTS
7. NUMBER OF TEACHERS IN SCHOOL
8. MAINTENANCE AND OPERATING COSTS
9. % INSTRUCTIONAL USE SPACE

(SEE MENU FOR HELP, IF NEEDED)

Fig. 44. Introductory screen for Total Daily Student Cost subprogram

[1]Classroom lecture of Robert Pittillo, Duke University, Durham, North Carolina, 13 February 1979.

```
WHAT IS THE CENTRAL ADMINISTRATIVE COST (IN
  DOLLARS)?  XXXX
WHAT IS THE TOTAL NUMBER OF TEACHERS IN THE
  SYSTEM?  XXXX
HOW MANY TEACHERS ARE IN THE SCHOOL?  XXXX
WHAT IS THE SCHOOL SERVICE COST?  XXXX
WHAT IS THE AVERAGE TEACHER COST SALARY?  XXXX
HOW MANY PERIODS DOES THE TEACHER TEACH?  XXXX
HOW MANY STUDENTS ARE IN THE CLASS?  XXXX

                HIT RETURN TO CONTINUE
```

Fig. 45. Screen gathering information for Total Daily Student Cost subprogram

```
THE COST FOR THE PROFESSIONAL SERVICES IS EQUAL TO XXXX
DOLLARS.

THIS, HOWEVER, IS NOT THE TOTAL COST TO THE SYSTEM.
NON-PROFESSIONAL SERVICES MUST BE INCLUDED.

                HIT ANY KEY TO CONTINUE
```

Fig. 46. Information gathering screen for Total Daily Student Cost subprogram

```
WHAT ARE THE TRANSPORTATION COSTS?  XXXX
WHAT IS THE TOTAL NUMBER OF STUDENTS?
  XXXX
WHAT ARE THE MAINTENANCE AND OPERATION
  COSTS?  XXXX
WHAT IS THE NUMBER OF STUDENTS IN THE
  SCHOOL?  XXXX
IF THE INSTRUCTIONAL USE SPACE IS NOT KNOWN TYPE (HELP)
AND RETURN, OTHERWISE JUST HIT RETURN
```

Fig. 47. Information gathering screen for Total Daily Student Cost subprogram

WHAT IS THE PERCENT OF INSTRUCTIONAL
USE SPACE? XXX
THE NON-PROFESSIONAL COSTS ALL EQUAL
XXXX DOLLARS.

HIT ANY KEY TO SEE THE TOTAL COSTS.

THE TOTAL COSTS PER DAY ARE XXXX DOLLARS.

HIT RETURN TO CONTINUE

Fig. 48. Summary screen for Total Daily Student Cost subprogram

From the menu selection, option 3 allows the user to keep a running account of the electric bill for the month. The first screen displayed is basically informational. The second requests the kilowatt-hour usage for the month and returns the cost based on the current charges of the electric utility. Figures 49 and 50 display how the screens would look. This subprogram is good for keeping track of energy use. The period of time does not have to be a month; daily figures could be obtained from reading the meter. As demand charges are applied, there may be some variation in this subprogram from calculated bill to actual bill. The information used is an average and should be of benefit from a budget standpoint at least as far as trends are concerned. Hitting a key will return the user to the menu for another selection.

Selection of option 4 will take the user through a series of screens designed to calculate energy consumed per square foot of floor area. The United States government has suggested that a goal of 55,000 Btu/square foot be set. This subprogram takes all of the energy usage in the building and

```
THIS ROUTINE ASKS CERTAIN QUESTIONS CON-
CERNING ENERGY COSTS.  IT WILL BE NECESSARY
FOR YOU TO OBTAIN THE NEEDED INFORMATION
FROM YOUR UTILITY COMPANY(IES) BEFORE
PROCEEDING.

DO YOU WISH TO UPDATE?  XXXX
YOU MUST TYPE 'LIST 3700, 3900.'  THIS
WILL LIST THE PROGRAM LINES CONTAINING
THE MATHEMATICS OF THE RATE SCHEDULE.
SIMPLY CHANGE THE RATES AS NEEDED.
AFTER THE CHANGES HAVE BEEN MADE TYPE
RUN AND THEN HIT THE (RETURN KEY).

THE DATA IN THIS PROGRAM ARE FOR DUKE
POWER CO. AS OF 1 JANUARY 1982.  IF THE
RATES CHANGE OR YOU ARE SERVED BY SOME
OTHER COMPANY YOU MUST INSERT THE UP TO-
DATE DATA IN LINES 3700-3900.

          HIT ANY KEY TO CONTINUE
```

Fig. 49. Informational screen for Energy Costs subprogram

```
WHAT WAS THE KWH CONSUMPTION FOR THE MONTH
YOU WANT TO KNOW THE COSTS?
ENTER THE KWH'S AND THEN HIT (RETURN) XXXX
WHAT IS YOUR BILLING DEMAND IN KILOWATTS?
  XXXX
YOUR COST FOR THE MONTH IS APPROXIMATELY?
  XXXX

          HIT RETURN TO CONTINUE
```

Fig. 50. Summary screen for Energy Costs subprogram

converts all forms to Btu equivalent and then sums and divides to give the user an approximation of energy use and how close to the goal the building comes.

There are three screens used in this subprogram and they are illustrated by figures 51-53. The first describes the Btu conversion

technique for the user. The second requests average monthly consumption figures for the listed energy sources. A final screen sums all the entered data and presents the Btu usage per month, per year, and gives the percentage of the national goal that has been achieved. A prompt is then provided asking if there are other buildings to be considered. A "Y" recycles the user through the program, any other response returns the user to the section menu for another selection.

```
THIS ROUTINE ALLOWS YOU TO DETERMINE HOW
CLOSE YOU ARE COMING TO MEETING THE
NATIONAL GOALS FOR ENERGY CONSUMPTION IN
ORDER TO MAKE THE COMPARISONS IT WILL BE
NECESSARY FOR YOU TO KNOW YOUR ENERGY USE
IN KWH; CUBIC FEET; GALLONS; ETC.

THE DATA THAT WILL BE PRESENTED WILL BE
BASED ON INFORMATION FROM THE PIEDMONT
CRESCENT ENERGY PROJECT AND REPRESENTS
THOUSANDS OF BTU.

                ENERGY DATA
                ===========

        ELECTRIC (KWH)..... 3.4
        OIL #2 (GAL).....138.69
        NAT. GAS (CCF).....103.0
        COAL (TONS).....24500.0
        LP GAS (GAL).....95.475

        HIT ANY KEY TO CONTINUE
```

Fig. 51. Introductory screen for BTU/SQ. FT. subprogram

```
TYPE THE NAME OF THE SCHOOL THEN HIT
RETURN XXXX

WHAT WAS YOUR TOTAL KWH USE?  YOU MUST USE
MONTHLY CONSUMPTION DATA IF THIS PROGRAM
IS TO WORK PROPERLY!  XXXX
WHAT WAS YOUR CONSUMPTION OF NATURAL GAS
  IN HUNDREDS OF CUBIC FEET (CCF/MONTH)?
  XXXX
WHAT WAS YOUR CONSUMPTION OF OIL IN
  GALLONS? XXXX
WHAT WAS YOUR CONSUMPTION OF COAL (IF ANY)
  IN TONS?  XXXX
WHAT WAS YOUR CONSUMPTION OF LP GAS IN
  GALLONS?  XXXX
ONE LAST BIT OF DATA NEEDED IS THE TOTAL
  SQUARE FOOTAGE OF THE BUILDING.  XXXX
```

Fig. 52. Informational gathering screen for BTU/SQ. FT. subprogram

```
YOUR MONTHLY BTU USE IS XXXX
THIS MAKES YOUR YEARLY CONSUMPTION = XXXX
  BTU
ON A SQUARE FOOT BASIS YOU HAVE USED XXXX
  BTU/SQUARE FOOT

THE NATIONAL GOAL IS TO USE ONLY XXXX
  BTU/SQ. FT.
THIS MEANS THAT YOU HAVE ACHIEVED ABOUT
  XX% OF THE NATIONAL GOAL.

DO YOU HAVE OTHER ENERGY COSTS (Y/N)?  XXX
```

Fig. 53. Summary screen for BTU/SQ. FT. subprogram

Selection of option 5--END--returns the user to the PRIMARY MENU. From the PRIMARY MENU it is possible to select option 3--PAYBACK. In this option it is necessary that the user have completed the information on the data sheet so that it can be entered into the computer's memory. The SRDAS presents an informational screen shown in figure 54. It is assumed in this subprogram that the school system does not have readily available funds with which to carry out energy modifications. If this is true, then the system

must borrow or obtain through some financing means the money to carry out energy improvements and pay the appropriate interest. It is important that the user understand that even if the money were to come from the state or the federal government, there is still a cost associated with getting the money which must come from the taxpayers. This cost includes higher taxes, cost of collection, and possibly cutting existing services in other areas.

```
THIS PROGRAM IS THE KEY ONE FOR DETERMIN-
ING THE NET EFFECT OF ANY ADDITIONS TO YOUR
BUILDINGS.
IN ORDER TO USE THIS PROGRAM WITH THE
GREATEST BENEFIT, IT WILL BE NECESSARY THAT
YOU HAVE COMPLETED THE OTHER PARTS OF THE
PACKAGE AND HAVE THE COMPLETED DATA SHEETS
BEFORE YOU.
THIS PROGRAM WILL ANALYZE THE CURRENT
SAVINGS, LOOK AT LONG-TERM SAVINGS AND
FIGURE PAYBACK TIME.
THIS WILL BE DONE IN A GENERAL MANNER
AND BE APPLICABLE TO ANY ENERGY SOURCE.
```

Figure 54. Introductory screen for Payback subprogram

The data sheet lists the information needed to complete this section. The information is gathered by the screens shown in figures 55-56. Savings from the various subparts are presented on the same screen as the information was gathered. Figure 57 representing the final screen in this subsection totals all the savings, looks at the original costs, and provides a "total worth savings" over the life of the loan.

New buildings or upgrades to existing buildings can be handled by this particular subsection. It is only through the use of such a subprogram as PAYBACK that any of the other analyses make sense.

A final prompt shown in figure 57 asks if there are other buildings that the user wishes to compare. This could be the same buildings with either more or less difference between them. It is possible to achieve the

```
WHAT IS YOUR INTEREST RATE?  XXX
WHAT IS THE NUMBER OF YEARS OF THE LOAN?
XXX
YOUR DEBT SERVICE CONSTANT IS XXXX
WHAT IS THE DIFFERENCE IN CAPITAL COSTS
  OF THE TWO STRUCTURES?  (DOLLARS) XXXX
YOUR AMORTIZATION COST FOR THE ADDED
  INVESTMENT IS XXXX
WHAT IS THE YEARLY O&M COST FOR SYSTEM A?
  XXXX
WHAT IS THE YEARLY O&M COST FOR SYSTEM B?
  XXXX
THE ANNUAL OPERATION AND MAINTENANCE
  SAVING IS XXXX
YOU COST BENEFIT RATIO IS XXXX
FOR THIS EXAMPLE IT IS ASSUMED THAT THE
  ENTIRE O&M SAVING WILL BE USED TO PAY
  OFF THE LOAN.
THE NUMBER OF YEARS TO PAY BACK THE LOAN
  IS XXXX.
```

Fig. 55. Information gathering screen for Payback

```
IN FIGURING THE TOTAL LONG TERM SAVING,
IT IS NECESSARY TO CONSIDER ANNUAL O&M
  AS WELL AS ADDITIONAL AMORTIZATION COST.
FOR YOUR BUILDINGS THIS AMOUNTS TO XXXX
THE PRESENT WORTH OF THE 20-YEAR DIF-
FERENCE IS XXXX
FOR THIS PART OF THE PROGRAM IT IS
NECESSARY TO KNOW ANNUAL FUEL COSTS FOR
  THE TWO BUILDINGS.
WHAT IS THE ANNUAL FUEL COST FOR NUMBER
  ONE?  XXXX
WHAT IS THE COST FOR BUILDING TWO?  XXXX
AN AVERAGE COST INCREASE OF 7% IS USED
  FOR FUEL COST.
ENERGY COSTS FOR BUILDING ONE ARE XXXX
  FOR THE 20 YEARS.
ENERGY COSTS FOR BUILDING TWO ARE XXXX
  FOR THE SAME PERIOD.
THIS RESULTS IN AN ENERGY SAVINGS OF XXXX
THE LIFETIME MAINTENANCE COSTS FOR
  BUILDING ONE ARE XXXX
THE LIFETIME COSTS FOR BUILDING TWO ARE
  XXXX
THIS RESULTS IN A MAINTENANCE SAVINGS OF
  XXXX.
```

Fig. 56. Information presenting screen for Payback

```
IN SUMMARY THE SAVINGS AND COSTS WHICH CAN BE ATTRIBUTED TO THE MORE
EFFICIENT STRUCTURE ARE:

        ENERGY SAVINGS.....$ XXXX
        MAINTENANCE SAVINGS....$ XXXX
        ORIGINAL COST.....( XXXX )

WHAT THIS AMOUNTS TO IS A PRESENT WORTH
SAVINGS FOR THE 20-YEAR PAYBACK OF THE
LOAN OF XXXX FOR BUILDING TWO...THE MORE
ENERGY EFFICIENT STRUCTURE.

DO YOU HAVE OTHER BUILDINGS YOU WISH TO
COMPARE?  (Y/N) XXX
```

Fig. 57. Summary screen for Payback

optimum benefit by using this subprogram as an analytical tool. When there are no more comparisons to be made the user hits the "N" and is returned to the PRIMARY MENU.

The example below is illustrative of the formulae used in the PAYBACK program. The information is from Educational Facilities Laboratories publication The Economy of Energy Conservation in Educational Facilities.

Comparison of HVAC systems for Chantilly School

A. BENEFIT/COST ANALYSIS

Total first cost System A	$1,123,100
Total first cost System B	$1,238,190
System B exceeds System A by	$ 115,090

Annual O&M Cost	System A	System B
Maintenance & repair	$ 24,000	$18,420
Energy (electric)	$ 94,660	$67,000
Total O&M	$118,660	$85,420

System A exceeds System B by $ 33,240

Assume a 20-year useful life for each system and a 5½% interest rate.

d = Debt service constant, a factor that multiplied by the total loan amount, or total principal, yields the annual debt service payment. The program figures this number using the formula:

$$d = \frac{r(1 + r)^n}{(1 + r)^n - 1}$$

in which r = interest rate
n = number of years to repay loan.

Constant = .0837
Amortization cost, D, for additional capital investment
D = .0837 x $115,090
= $9,620

$$\text{Benefit/cost ratio} = \frac{\text{Annual O\&M saving}}{D} = \frac{\$33,240}{\$\ 9,620}$$

= 3.4 (a tremendous advantage for System B)

B. TIME TO RECOUP INVESTMENT

To find how long it would take to recoup the additional $115,090 capital cost investment required for System B, assume that the entire $33,240 O&M saving is applied to paying off a loan for $115,090 for n years at 5½% interest.

$$n = \frac{\log \frac{S/rC}{S/rC-1}}{\log(1+r)}$$

In which C = additional capital cost ($115,090)
S = annual O&M saving ($33,240)
r = .055 (interest rate)
n = number of years to pay off capital debt with an annual debt service payment equal to S, which in this example is $33,240.

$$n = \frac{\log \frac{33,240/.055 \times 115,090}{(33,240/.055 \times 115,090 - 1)}}{\log(1 + .055)}$$

n = 4 years

C. TOTAL LONGTERM SAVING

HVAC System A
Annual O&M cost = $118,660
HVAC System B

Annual O&M cost	=	$85,420
Additional amortization		$ 9,620
Total		$95,040

Difference, S = $118,660 - $95,040

S = $23,620

$$\text{Present worth} = S \frac{(1 + r)^n - 1}{r(1 + r)^n} = 23,620 \frac{(1.055)^{20} - 1}{.055(1.055)^{20}}$$

Present worth of 20-year difference = $ 23,620 x 11.95
= $282,000

D. COST-SAVING WITH RISING FUEL RATES

Assume that energy costs rise at an annual rate of 7% (geometric progression). What would be the total 20-year saving?

Annual energy cost: System A $94,660
System B $67,000

If the energy cost rises g% per year, the following formula holds:

$$\text{Present worth of total energy cost} = F \frac{a(a^n-1)}{a-1}$$

In which F = Original (year 0) annual fuel cost
g = annual rate of fuel increase (starting with first year's cost = F(1+g)
n = number of years
r = interest rate

$$a = \frac{1+g}{1+r}$$

	System A	
Energy cost	= $94,660 x 23.29 =	$2,205,000
Maintenance	= $24,000 x 11.95 =	$ 287,000
First cost		$1,123,000
Total "present worth"		$3,615,000

	System B	
Energy cost	= $67,000 x 23.29 =	$1,560,000
Maintenance	= $18,420 x 11.95 =	$ 220,000
First cost	=	$1,238,000
Total "present worth"		$3,018,000

"Present worth" of 20-year cost saving for System B = $597,000.[1]

The payback subprogram does all the calculations required to obtain the figures for analysis. It is not necessary that the user be a mathematician.

Since there are no further options on PRIMARY MENU except END (option 4) selecting this option loads the ending subprogram. The END subprogram consists of an APPLE II graphic and a "thank you for using the program." When this point has been reached, the user may remove the disk from the machine, turn off the power, and consider the amount of analysis that was done and its impact on the school or system using it.

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[1]Energy Facilities Laboratories, The Economy of Energy Conservation in Educational Facilities, 2nd edition (New York: Energy Facilities Laboratories, 1978), pp. 57-68.

CHAPTER V

SUMMARY AND CONCLUSIONS

The surveys which were presented in chapter II show the seriousness of the energy shortfalls as they impact schools. Activities of the federal and state governments in the area of energy which were reported in chapter III require administrators to become knowledgeable or to lose grant money or worse, not to be able to provide adequate staff. Administrators will find that the use of the series of programs presented in chapter IV will enable them to evaluate upgrades for existing buildings as well as conservation features in new construction.

Chapter II presented three surveys which are important to school administrators. Each survey will be briefly examined and its impact on SRDAS explained.

The survey conducted by the American Association of School Administrators (AASA) described fuel types that are utilized by the nation's schools.[1] These same fuel types are presented for analysis in the model program. Analysis of the data from this AASA survey indicates that school regions are differentially affected by energy source perturbations. The SRDAS allows the regional differences to be accounted for in terms of localized costs and potential fuel source changes in existing buildings.

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[1]American Association of School Administrators, AASA Energy Use Study (Arlington, Va.: American Association of School Administrators, August 1979), passim.

The same ability exists for analysis of energy sources for proposed buildings.

American School and University magazine published several surveys dealing with energy trends in heating sources.[1,2] The SRDAS program allows administrators to compare payback periods for various heating options. The ability to examine different scenarios greatly enhances the administrator's decision-making ability.

A survey requesting administrators to enumerate reasons for inaction provides several potential uses of the SRDAS program. One of the primary reasons given for inaction was the inability to suggest improvements which would improve energy efficiency. The modeling capability of the program would remove the credibility of this objection. An additional benefit of the use of the SRDAS program is the ability to determine quantitative savings rather than to make only a qualitative determination.

Chapter III presented three major pieces of federal legislation which had an impact on school energy management. In addition, several state laws from North Carolina and regulations from the North Carolina State School Board were presented. The school administrator in North Carolina is under legal mandate to conserve. This mandate, as described in chapter III, can be partially met through the utilization of the analysis program. The primary assistance of SRDAS to school administrators is in the alternative decision-making scenarios.

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[1]Abramson, Paul, "Educational Construction," American School and University 53 (April 1981): 48-58.

[2]Abramson, Paul, "Tenth Annual Maintenance and Operation Cost Study," American School and University 53 (March 1981): 58-66.

Chapter IV is a description of the execution of the various programs found in SRDAS. Use of the program is not difficult. The sample run was conducted by the principal of Newell Elementary School, who before using SRDAS had no computer experience. The sample run and a step-by-step explanation is found in the appendix.

There is nothing in the computer program which could not be done by hand calculations. One value of the School Retrofit Design Analysis System is the nontechnical tool offered to the administrator for evaluation of a highly technical subject. SRDAS can be readily available to school administrators for use with a relatively small investment of time. The program provides a flexible enough tool to be used in most school energy analyses.

By using SRDAS, the school administrator can provide informed guidance both within the organization and in dealings with outside agents such as vendors and engineers. Perhaps the most value, from an internal perspective, lies in the ability to utilize the program as a tool in conducting feasibility studies. These studies can be performed for analyzing simple modifications or complex retrofits. It is also possible to perform calculations for various scenarios concerning new building construction.

Modeling various energy modification alternatives without consuming a great deal of time will enhance the administrator's ability to gauge the relative effectiveness of alternative courses of action. The ease and simplicity of the model will facilitate its use as an administrative tool.

Having the ability to evaluate alternative plans will help the administrator's final decision to have more credibility. It will be much easier to present a convincing argument for a particular course of action if

the alternative courses have already been examined and found not be as desirable. SRDAS can provide the extra evidence needed to convince a school board of the appropriateness, from an energy perspective, of specific actions taken regarding retrofit or new building construction.

In addition to the credibility administrators can gain with school boards by being well prepared, architects and engineers will likewise be impressed by an energy knowledgeable administrator. The architects and engineers hired by the system can be dealt with more intelligently by an administrator who has utilized SRDAS to check the advisibility of certain design features from an energy standpoint. By demonstrating to the architect that energy conservation is important, the administrator can save many dollars for the system.

Another way to save school district money is through intelligent dealings with another outside agent--the vendor of energy conservation equipment. At times the claims of vendors seem too good to be true, but there is often no simple method of assessing the claims. Using SRDAS to aid in evaluation of energy conservation claims can save a system from a costly mistake. The flexibility designed into SRDAS allows it to be used to evaluate almost any energy savings claim.

All energy savings questions can not be solved using SRDAS. A majority can be successfully resolved using the modeling ability of the program to explore the effects of different courses of action. Administrators using the program may be able to save thousands of dollars in choosing the optimum way to invest limited dollars. Possibly the stature of the administrator as an astute business person will be increased through the more thoughtful decisions SRDAS makes possible.

APPENDIX A

SAMPLE RUN FOR NEWELL ELEMENTARY SCHOOL - 1958 BUILDING

Newell Elementary School is located in Newell, North Carolina. The school is located on Old Concord Road in the northeast part of the greater Charlotte area. The school consists of two buildings - one of these is the 1958 building on which the sample run will be conducted. The other is a building that has been built in stages, in 1970, 1976, and 1982.

The 1958 building is a building with classrooms on either side of a central hallway. There are eight classrooms in this section. The walls of these classrooms are primarily glass with eight windows per classroom, each 3 feet wide and 6 feet tall. The total floor area in the building is 9,298 square feet. Heat is provided by an oil furnace. The roof is flat and comprised of built-up tar and gravel. The walls are a brick veneer over a cinder block support.

The sample run will begin with a series of programs called Building Analysis, will procede through Btu/Sq. Ft. and finally end with the Payback program. Use of the data sheets which are part of this appendix makes running the programs much easier. The data sheets are completed prior to beginning the program run and then the information is simply transferred from the data sheet in response to the inquiries during the running of the program. In order to understand the sample run, it will be necessary for the user to consult both the data sheet and the computer print out of the sample run. The information requested on the data sheet will be indicated by identical numbering between the data sheet and the sample run.

Information which the user enters will also be underlined on the sample run for ease in understanding. The computer program indicates, for those users who have an interest, engineering formulae used and the assumptions which are made in the use of each formula.

In the evaluation of the building at Newell Elementary School improvements will be considered to the roof, the walls, the windows, and improvements in infiltration losses. Floor improvements will not be considered in this example because the floor in this area is of slab-on-grade construction.

When the Building Analysis subprogram begins, there is some information which appears on the video screen and the user is requested to look over a list for which analyses may be made and select the one desired. Once the selection is made for the roof, the video screen clears, some additional information is presented, and then a series of questions is asked of the user. The first question is "Do you have a flat built-up roof?" This corresponds to information on the data sheet for 1-a. A positive response to this question for built-up roof causes the program to proceed. Likewise, a negative response for a built-up roof causes the program to move on to pitched roof, with a series of questions about that roof. In the case of the Newell building, it is a built-up roof, so a positive answer provides information to the user that the calculations done for the built-up roof are based on the formula $Q/A = U\Delta T$. Since the built-up roof was selected, the next question presented to the user is, "What are the dimensions of the roof." The dimensions of the roof for Newell are 140 feet by 70 feet. The computer then goes through a series of calculations figuring the area of the roof and holds this figure in the computer memory, until another series of questions have been answered. "Have there been additional insulating

materials added to the roof" or "Do you wish to find out what the effect of proposed additions would be." A positive response to either of these questions will present the user with some more information and an instruction to find out the R-value of the added insulation. This corresponds to 1-f on the Building Analysis Sheet. In the case of Newell Elementary, a rigid roof insulation is being proposed with an R-value of 4.17.

The computer then takes the area of the building, the basic heat loss through a flat roof and the additional insulation and computes the loss based on the formula of heat transfer. In the case of Newell, the heat loss with this amount of insulation is 46,622 Btu per hour. Since there is a consideration of additional insulation, the screen displays a message indicating a savings of 30,797 Btu per hour.

On the data sheet under Building Analysis, these numbers are recorded in the roof loss and insulation savings areas. These are the shaded areas on the data sheet.

The program will take the insulation savings in Btu per hour and store it for use in computing the total Btu savings in the building.

After the roof savings are presented to the user, the program returns to the original listing, asking if there are any further items that need to be examined. In this example, floors will not be used because of the slab-on-grade construction. A selection will be made in this example for number 3 from the listing, which is infiltration.

When infiltration is selected, information concerning the assumptions will be presented and a series of questions asked of the user, who will respond with either yes or no answers or by filling in the appropriate information. Again, this information should have been filled in on the data

sheet prior to running the program. It will simply be a matter of transferring information from the data sheet in response to the computer inquiries.

The answer to the first question "Do you have brick walls?", as can be seen from the data sheet (3-a), is "Yes." The area of the wall is requested and can be found on the data sheet (3-b). In the case of the Newell School, it is 3,826 square feet, which is entered in response to the question.

The next series of questions ask for a selection describing the window fit. From the data sheet (3-c), the windows are loosefitting with or without weatherstripping.

The next question deals with the total perimeter of all windows, the data sheet (3-d) shows that the perimeter area is 1,152 feet.

The next question asks for the type of set of the windows, whether or not they are in masonry walls and caulked or frame walls and caulked. From the data sheet, (3-e), they are in a masonry wall and they are not caulked.

The program then presents the formula upon which the calculations are based, that formula being $U=MC\Delta T$. A series of calculations based on that formula is performed and the infiltration loss in the Newell School, the 1958 building, is found to be 107,380 Btu per hour. The program then requests whether or not there have been additional insulating materials added, or if the user wishes to see their effect.

In the case of Newell Elementary, replacement of the windows and caulking around the windows is considered in the example. Replacement would be with windows of equal size, but which are weatherstripped and tight-fitting. The program proceeds through the same series of questions as in the previous example. The user in this case indicates what improvements have been made, or what improvements should be considered by the program.

Again, based on the formula, $Q=MC\Delta T$, it found that the insulation and improved windows reduces heat loss due to infiltration to 29,620 Btu per hour. The program indicates that this is a savings of 77,760 Btu. Each of these numbers should be entered on the data sheet in the appropriate places under item 3.

Again, the computer files the Btu savings data for compilation into a total Btu savings when this segment of the program is complete.

The program returns the user to the main listing again, and an additional selection may be made. In the case of the Newell Building, since there is a desire to see improvement to the walls, selection number 4 is made. Information is presented to the user using the assumptions upon which the calcultions are based, and describing the basic wall that is considered. The formula used for the calculation is presented, that formula being $Q=UA\Delta T$. The program continues, requiring response from the user, asking the total square footage of the wall, minus the window area. From the data sheet (4-a), this information, which in the case of Newell is 2,574 square feet, is entered. Calculations using the formula are carried out by the program and heat loss from the basic wall is equal to 37,194 Btu per hour. This figure is listed in the appropriate space on the data sheet. The user is then queried as to whether or not additional insulating materials have been added or proposed. A positive response will present a listing of seven of the more common wall additions, and ask the user to list the total R-value from any additions or from any additions contemplated. The user is instructed that if the material which is being considered is not listed, then the R-value should be obtained from the vendor of that particular material. In the case of the Newell building, an addition of spray-on

cellulose material plus one-half inch gypsum wall board is considered, for an addition of 4.15R.

The computer, using the formula listed earlier, calculates that with this amount of insulation, the heat loss is now 16,867 Btu per hour, or a difference from the primary wall to the insulated one of 20,327 Btu per hour. The insulation savings should be entered on the data sheet in the appropriate space. Once the wall segment has been completed, the program returns to the main listing asking if there are any other items which should be considered.

In the case of Newell Elementary, windows will be considered for upgrade. Information about windows and the basic assumptions made about the windows are presented to the user.

A series of questions concerning the orientation of windows is presented and the user enters the appropriate data. This data comes from the data sheet, which has been prepared prior to running the program. The orientation data is 5-a on the data sheet.

Window areas facing north, northeast, east, southeast, and so on are entered at the appropriate time. In the case of the building at Newell, there are window areas facing northeast, southeast, and southwest. Once the orientation and the area facing in the particular direction has been entered, questions as to the type of window are presented. In the case of Newell, there is single glass construction, so "yes" to the first question causes the program to continue. A negative response to a single glazing would continue the program and ask the user about double glazed and storm windows. The heat coefficient formula, which will be used, will be $Q=UA\Delta T$.

With the single glazed window in the Newell School, the window loss is equal to 63,359 Btu per hour. This number should be listed in the

appropriate place on the data sheet. The user is then queried as to whether or not upgrades to the windows should be considered. In the case of Newell, the addition of storm windows is the proposed improvement. Therefore, a yes response to that particular question causes the program to proceed. Indicating that storm sashed windows have a heat loss equal to 28,800 Btu per hour, the program provides the difference between the loss of the single glazed windows and the storm windows. This insulation savings should be entered in the appropriate place on the Building Analysis Data Sheet. Once no further upgrades to the windows are to be considered, a solar heat gain factor is figured for the given window orientations.

It is assumed that the heat gain is for the month of December and the figure, 82,160 Btu per hour for the Newell building, should be listed in the appropriate place on the data sheet.

Once again, the program returns the user to the main menu, asking if there are any additional items to be considered. It also allows for reconsideration of any of the items.

In the case of the Newell School, there are no additional items to be considered, and there are no items to be reconsidered. Thus, by indicating that the program should end through selection of number 6 from the listing, the computer will total all the Btu savings from the various changes, additions, and modifications that were selected in the program. This number should be recorded in the appropriate place on the Building Analysis Data Sheet.

Btu Per Square Foot

The Btu per square foot program accomplishes several things in addition to figuring Btu per square foot. It is a multiple program having four parts. One of these parts figures the percent of instructional use

space in the building. A second part computes the daily student costs which are attributable to administration, operation and maintenance, transportation, and so on. A third part figures energy costs on a continuous basis. The final part of the program computes the Btu used per square foot and allows the administrator to find out how close to the national goal the school has come.

As was the case in the Building Analysis program, after each subpart in the program, the user is returned to the main listing of options. At any point from that listing, the program may be ended. In the case of the Newell School, however, each of the four options from the listing will be selected in order. The data from the data sheet will be listed on the sample run by identical numbers, so that the user may compare information from the data sheet to see where it is utilized in the program.

The Btu Per Square Foot Program provides information to help the user understand budget costs, as they relate to energy use.

The main listing is presented and selection number 1, (percent instructional use space) is made for use in the example. Information as to what this particular subprogram does is presented to the user. The program then queries the user on the area of the facility in square feet. From the Data Sheet (1-a), the total area for Newell Elementary School is 62,306 square feet. Next the program queries the user on the number of square feet devoted to instructional purposes. In the case of Newell, this does not include the media center, the cafeteria, and the multi-purpose room. When each of these specialized rooms are in use, other classrooms have been vacated. The total area devoted to instructional purposes at Newell Elementary is 38,432 square feet, as can be seen from the Data Sheet (1-b). This figure is entered in response to the question. The computer figures

the percentage of instructional use space as 61%. After this number is placed in the proper area on the data sheet, the user can return to the primary listing and select item number 2, total daily student costs. Information is presented to the user, indicating the items which should be known prior to running this particular segment of the program. These items are listed on the data sheet (2-a through 2-1).

Questions are asked about each of these items. Answers should be entered from the Data Sheet. In the sample run, they are indicated using the identical numbering system.

Costs are broken down into two categories. One is the cost for the professional services which would include the central administrative cost, the total number of teachers in the system, how many teachers are in the school, the school service cost, the average teacher's salary, and the number of students in the class. In the case of our example, a primary classroom was analyzed, which in 1982 had a legal limit of 26 students in North Carolina.

However, consideration of the professional services is not all that goes into figuring a per student cost. There are transportation, maintenance, and operation costs which must be considered. This information is entered from the Data Sheet in response to questions from the program. The non-professional costs are computed and presented to the user. The costs should be placed in the appropriate space on the Data Sheet. The total cost of both professional and non-professional components are presented to the user. This total cost should be entered in the appropriate place. The administrator, by using these figures, can arrive at costs on a per pupil basis.

The next subprogram to be run is Energy Costs (electric). Within the program are rates for Duke Power Company as of 1 January 1982. These rates may be updated by the user by answering "Yes" to the question "Do you wish to update?" In the case of the example, the rates for Newell Elementary School are correct as listed within the program. So to the question "Do you wish to update?" the response is "No" and the program continues.

A series of questions is presented to the user. The information can be entered from the data sheet (3-b) and (3-c). If the user does not know the requested figures, current data may be obtained by contacting the local utility office, which can provide the information. In the case of Newell, the month's use was equal to 36,495 kilowatt-hours, with a billing demand charge of 5 kilowatts. The program utilizing the current schedule indicates the cost for the month is approximately $1382.77. Knowing this figure can be very helpful in managing school budgets.

Once again, the user is returned to the main listing, and item number 4 can be selected (Btu per square foot). The information presented to the user indicates some of the basic assumptions which have been made in determining the Btu per square foot figures. The Btu per square foot data can be obtained whether heating is electric, oil, natural gas, coal, or LP gas. All that is needed is the average monthly consumption for these items for a year. In the case of Newell, there are only two energy sources which are used and these are electricity and oil. The average figures are entered in response to the queries for kilowatt-hours and gallons of oil. Newell averages using 54,717 kilowatt-hours per month and 1,069 gallons of oil per month. In each case, the usage is not spread evenly over the year, but since the program is figuring yearly use the average is sufficient. One

additional bit of information is needed and that is the area of the building which is obtained from the data sheet (1-a).

The computer then figures, based on the average kilowatt-hours and the average gallons of oil consumption, the total number of Btu which were used at Newell Elementary School. The program calculates on a square foot basis that Newell used 64,384 Btu. Since the national goal is to use only 55,000 Btu per square foot, the program displays the percentage that Newell achieved of the goal (85%). Both the number of Btu per square foot and the percentage of the national goal should be listed in the appropriate place on the data sheet.

Once again, the user is returned to the main listing, and since the example has considered each of the items listed, item number 5 should be selected which will end this series of programs.

The Btu/Sq. Ft. subprogram is useful in the day-to-day operation of the physical plant by helping to determine the various costs of that operation.

Payback

The payback subprogram is perhaps the most important of SRDAS. This program allows the administrator to determine the net effect, in terms of dollars and cents, of any modifications or improvements to the building or buildings in question. An informational screen is presented to the user indicating what components this particular program examines. The components are analysis of current savings, a look at long-term savings, and a figuring of payback periods.

There is a section of the program at the beginning which requests fuel costs for each type of fuel to be considered in the analysis. Each energy source which is affected through the modification of the building should be

listed at this point. In the event that a source is not involved in the proposed modifications, the program instructs the user to enter a 0 as the cost. This information comes from the data sheet (1-a).

The next section asks for the number of Btu that are saved by the additions. This also comes from the data sheet (1-b). The amount of savings in terms of Btu is figured from the total on the Building Analysis Data Sheet. In the case of Newell Elementary, there are only two sources which could be potentially affected by changes, electricity and oil. The current cost for electricity at Newell is about 5¢ per kilowatt-hour, and the cost per gallon of oil is about $1.03. In the case of the building change at Newell, all of the additions are affecting the heating system. The heating system in the 1958 building at Newell Elementary is oil, therefore, all of the Btu saved in the example will be assumed to be Btu savings from oil. This is a conservative estimate because obviously, if the furnace does not run as much, there will be electrical savings as well due to circulating pumps and firing pumps. The real savings, therefore, will probably be somewhat greater than the savings listed in this program and the real payback period will be somewhat less than that listed.

The assumptions made, however, produce a very conservative estimate of costs and savings. The program takes the cost per gallon of oil, in this case $1.03, and the total Btu savings, in this case 460,183,139 Btu and converts these data into a dollar savings figure. The dollar savings at the Newell School, given the cost of oil and the Btu saved would be $3,417. This should be entered in the appropriate place on the data sheet.

The next series of questions are economic questions. The first question asked is the interest rate. The current interest rate for the

Charlotte-Mecklenburg Schools in 1981 was between 9 percent and 10 percent. For the purpose of this example, 9.5 percent has been chosen.

The next question asks for the useful life of the addition. Financing is assumed for the duration of that life, again this is a conservative assumption. The additional improvements to the building at Newell are expected to last the life of the building which is an additional 30 years. The 30 year number is obtained from the data sheet (2-b). These numbers are utilized to give a debt-service constant of .101, which is listed in the appropriate place on the data sheet. Since the improvements being considered are retrofit improvements, the difference in capital costs between the two structures will merely be the cost of the improvements. In the case of the Newell School, the cost of improvements is approximately $34,800. The additional cost for financing over the time period is calculated. The number should be entered in the appropriate place on the data sheet.

The next questions are for operational maintenance costs comparing System A and System B. In the case of the Newell School, since the only thing being affected is fuel cost, the boiler is not being changed or modified, a conservative method is to simply look at the number of Btu saved and the cost for that number of Btu. The fuel costs for the building at Newell in 1980 were $13,316. The number of Btu used, assuming all of the retrofit procedures had been accomplished, would be 89% of 1980's total. The operation and maintenance cost for fuel only should be $9,899. The annual operation and maintenance savings would be $5,417 for a cost/benefit ratio of 1.53. The number of years to pay back the loan, based on operation and maintenance cost, amortization cost, and original capital cost would be

10.4 years. This number should be listed in the appropriate place on the data sheet.

In figuring long-term savings, it is necessary to consider annual operation and maintenance as well as the additional amortization cost. Over the 30-year period of useful life of the building, that difference is worth about $18,474. This number should be listed in the appropriate place on the data sheet. One of the things, however, that is important to consider is that fuel costs are increasing. If one assumes an average cost increase of 7 percent a year for fuel, the energy savings over the 30-year life of the building, as figured by the program, would be $115,892.

In the example, annual fuel costs for System A would be $13,216 and for System B would be $9,899. These figures are obtained from the data sheet.

Since no maintenance would be saved or caused by the addition, a summary of the savings and costs which can be attributed to the structure, are presented to the user. Energy savings of almost $116,000, maintenance savings of nothing, and original costs of $34,800. There would be a present worth savings in current dollars with inflated energy costs of a 30-year payback period of the loan of $81,092 for the building that had been upgraded. This number should be entered into the appropriate place on the data sheet.

Summary

Using the practical energy model program will provide the administrator with the ability to make informed judgements based on the data which are available. In order that the administrator have some insight into the assumptions and calculations of what is happening, the program describes and displays the formulae which are used in calculating the results. In addition, a flow chart for each of the subprograms is provided in appendix

B. The completed data sheets for the Newell Building and blank data sheets to be used in figuring for additional buildings are provided in this appendix.

An administrator desiring to use this series of programs may have them entered into any computer programmed for basic computer language. A listing of the programs is found in appendix B. A magnetic copy of the program specifically designed for use on the Apple II microcomputer is available upon request from the author.

The following information represents the sample run of SRDAS done for Newell Elementary School.

THIS PROGRAM IS DESIGNED TO HELP SCHOOL ADMINISTRATORS DETERMINE THE ENERGY USE, NEEDED ENERGY IMPROVEMENTS, AND PAYBACK PERIODS FOR THEIR SCHOOLS.

THIS PROGRAM IS PART OF A DOCTORAL
DISSERTATION IN SCHOOL ADMINISTRATION FROM DUKE UNIVERSITY

PREPARED BY STEPHEN L CANIPE

DECEMBER, 1981

HIT ANY KEY TO CONTINUE

MENU

CHOOSE FROM THE MENU THE OPERATION THAT YOU WOULD LIKE TO SEE. SELECT BY THE NUMBER, PLEASE!

1. BUILDING ANALYSIS
2. BTU/SQ. FT.
3. FIGURE PAYBACK PERIOD
4. END

DATA SHEET
Building Analysis

1. Roof loss _____ Insulation savings _____
   a. type — built-up _____
      pitched _____
   b. type insulation (pitched) _____
   c. dimensions (pitched) _____
   d. dimensions (flat) _____
   e. suspended ceiling (Y/N) _____
   f. R-value of installed or proposed addition _____

2. Floor loss _____ Insulation savings _____
   a. slab-on-grade _____
   b. crawl space _____
      - dimensions _____
      - R-value of installed or proposed addition _____

3. Infiltration loss _____ Insulation savings _____
   a. type wall (brick, wood) _____
   b. wall area _____
   c. type window fit (loose, weatherstripped) _____
   d. perimeter measure of windows _____
   e. window caulking and condition _____

4. Wall loss _____ Insulation savings _____
   a. wall area minus window area _____
   b. R-value of proposed or installed addition _____

5. Window loss _____ Solar heat gain _____ Insulation savings _____
   a. glass area facing: N _____ S _____ E _____ W _____
      NE _____ SE _____ NW _____ SW _____
   b. type window: single glazed _____
      double glazed _____
      storm window _____

6. Total Btu saved _____

DATA SHEET
Building Analysis

1. Roof loss 77,419 Btu Insulation savings 30,797 Btu
   a. type — built-up yes
      pitched
   b. type insulation (pitched)
   c. dimensions (pitched)
   d. dimensions (flat) 140' x 167'
   e. suspended ceiling (Y/N) N
   f. R-value of installed or proposed addition 4.17 (rigid roof board)

2. Floor loss 0 Insulation savings NA
   a. slab-on-grade ✓
   b. crawl space
      - dimensions
      - R-value of installed or proposed addition

3. Infiltration loss 107,380 Btu Insulation savings 77,760 Btu
   a. type wall (brick, wood) brick
   b. wall area 3726 ft²
   c. type window fit (loose, weatherstripped) loose
   d. perimeter measure of windows 1152
   e. window caulking and condition none

4. Wall loss 37,194 Btu Insulation savings 20,327 Btu
   a. wall area minus window area 2574 ft²
   b. R-value of proposed or installed addition 4.15 (cellulose spray + wall board)

5. Window loss 63,359 Btu Solar heat gain 182,160 Btu Insulation savings 34,559 Btu
   a. glass area facing: N 0 S 0 E 0 W 0
      NE 432 ft² SE 288 ft² NW 0 SW 432 ft²
   b. type window: single glazed ✓
      double glazed
      storm window

6. Total Btu saved ~~288,11523~~ 460,183,139 Btu

(Fill in the lettered blanks before running the Building Analysis program.)

B U I L D I N G A N A L Y S I S

THIS PROGRAM WILL EXAMINE VARIOUS
ASPECTS OF SCHOOL HOUSE DESIGN AND WILL
DETERMINE THE BTU LOSS (OR GAIN) FROM
FROM THE VARIOUS COMPONENTS

THE MENU BELOW WILL ENABLE YOU TO SELECT ANY SPECIFIC COMPONENT OR ALL OF THEM.
HIT ANY KEY TO CONTINUE

M E N U

1. ROOF
2. FLOORS
3. INFILTRATION
4. WALLS
5. WINDOWS
6. END

SELECT OPTION BY NUMBER -- 1

THIS PART OF THE PROGRAM WILL ASK YOU
SEVERAL QUESTIONS ABOUT THE ROOF ON THE
BUILDING(S) IN QUESTION.

YOU SHOULD RESPOND WITH (Y) OR (N) TO
EACH QUESTION. IN THE EVENT YOU HAVE
ADDED ADDITIONAL INSULATING MATERIALS
YOU WILL BE REQUIRED TO TYPE IN THE
CORRECT VALUE FROM THE TABLE WHICH WILL
APPEAR ON THE SCREEN.
HIT ANY KEY TO CONTINUE...
DO YOU HAVE A FLAT, BUILT-UP ROOF?(Y/N)

```
THE CALCULATIONS DONE IN THIS SECTION
ARE BASED ON THE FORMULA:


     Q/A=UΔT

WHERE Q= HEAT TRANSFER; A= AREA
U=HEAT TRANSFER COEFFICIENT; AND ΔT=
CHANGE IN TEMPERATURE.


THE DESIGN TEMPERATURE USED IS 18 DEG-F
AT THE WINTER CONDITIONS AND 93 DEG-F
AT THE SUMMER CONDITIONS.
SINCE THE WINTER CONDITIONS ARE MOST
SEVERE THEY WILL SERVE AS THE BASIS FOR
CALCULATIONS.
     HIT ANY KEY TO CONTINUE
WHAT ARE THE DIMENSIONS OF YOUR ROOF?  140
??70

DO YOU HAVE A SUSPENDED CEILING?  (Y/N) -- N
HAVE THERE BEEN ADDITIONAL INSULATING -- N
MATERIALS ADDED TO YOUR ROOF? (Y) OR (N)
ROOF INSULATION IS PERFORMED AND IS USED
ABOVE THE METAL DECK.  DIFFERENT MANUFACTURERS
HAVE DIFFERENT INSULATING PROPERTIES IN THEIR
ADDITIONS


IT WILL BE NECESSARY TO CONSULT A
SPECIFIC MANUFACTURER TO DETERMINE R-
VALUES.  (THE RANGE IS 2.7 TO 20.)

IF YOU HAVE A SUSPENDED CEILING IN YOUR
PLANS ADD AN R-VALUE OF 1.0 TO THE
TOTAL R-VALUES FOR THE EFFECT OF THE AIR
SPACE.
REMEMBER TO ADD THE TILE'S R-VALUE
ALONG WITH THE AIR SPACE AND ANY OTHER
ADDITIONS.
HIT ANY KEY TO CONTINUE
WHAT IS THE R-VALUE OF THE MATERIAL?  4.17
THE HEAT LOSS WITH THIS AMOUNT OF INSULATION
IS 46622 BTU/HR.
THIS IS A SAVINGS OF 30798 BTU/HR.
HIT ANY KEY TO CONTINUE
```

```
                    M E N U

          1.    ROOF
          2.    FLOORS
          3.    INFILTRATION
          4.    WALLS
          5.    WINDOWS
          6.    END


SELECT OPTION BY NUMBER -- 2
THIS PART OF THE PROGRAM WILL ASK YOU
SEVERAL QUESTIONS ABOUT THE FLOOR IN
THE BUILDING(S) IN QUESTION.

YOU SHOULD RESPOND WITH (Y) OR (N) TO
EACH QUESTION.  IN THE EVENT YOU HAVE
ADDED ADDITIONAL INSULATING MATERIALS
YOU WILL BE REQUIRED TO ENTER THE
CORRECT VALUE FROM THE TABLE WHICH WILL
APPEAR ON THE SCREEN.
HIT ANY KEY TO CONTINUE...
DO YOU HAVE A SLAB-ON-GRADE FLOOR?  (Y) OR (N) -- Y
YOU HAVE NO APPRECIABLE HEAT LOSS
THROUGH THE FLOOR.  FOR THE PURPOSE OF
THIS ANALYSIS YOU MAY CONSIDER THE LOSS
EQUAL TO 0 BTU/HR.


HIT ANY KEY TO CONTINUE


THE MENU BELOW WILL ENABLE YOU TO SELECT ANY SPECIFIC COMPONENT OR ALL OF
THEM.
HIT ANY KEY TO CONTINUE
```

```
          M E N U

     1.   ROOF
     2.   FLOORS
     3.   INFILTRATION
     4.   WALLS
     5.   WINDOWS
     6.   END


SELECT OPTION BY NUMBER -- 3
THIS PART OF THE PROGRAM WILL ASK YOU
SEVERAL QUESTIONS ABOUT INFILTRATION IN THE BUILDING(S) IN QUESTION.

YOU SHOULD RESPOND WITH (Y) OR (N) TO
QUESTIONS OR BY ENTERING NUMBERS AS
REQUESTED.
HIT ANY KEY TO CONTINUE...
IN ORDER TO FIGURE INFILTRATION IT IS
NECESSARY TO HAVE VALUES FOR WALL
SQUARE FOOTAGE AND WINDOW PERIMETERS.
IT WILL BE NECESSARY TO MAKE SOME
ASSUMPTIONS ABOUT THE VENTILATING AIR
AND BUILDING PRESSURIZATION.
DO YOU HAVE BRICK WALLS? -- Y
WHAT IS THE AREA OF THE WALL (SQ. FT.) 3826
FROM THE FOLLOWING SELECT THE ONE WHICH
BEST DESCRIBES YOUR WINDOWS:
     1.   LOOSE FITTING WITH OR WITHOUT
          WEATHERSTRIPPING
     2.   AVERAGE FIT WITH WEATHERSTRIPPING
     3.   AVERAGE FIT WITHOUT WEATHERSTRIP
ENTER THE NUMBER -- 1
WHAT IS THE TOTAL PERIMETER IN FEET OF
ALL WINDOWS?
?1152
SELECT HOW YOUR WINDOWS ARE SET FROM
THE FOLLOWING MENU:
     1.   MASONERY WALL, NOT CAULKED
     2.   MASONERY WALL, CAULKED
     3.   FRAME WALL, CAULKED OR NOT


ENTER NUMBER -- 1
THE INFILTRATION CALCULATIONS ARE BASED
ON THE FOLLOWING FORMULA
          Q=MCΔT
```

```
WHERE Q= HEAT LOSS IN BTU/HR; M=MASS OF
AIR;C=SPECIFIC HEAT; AND ΔT=CHANGE IN
TEMPERATURE
HIT ANY KEY TO CONTINUE
THE TOTAL HEAT LOSS DUE TO INFILTRATION
IS 107380 BTU/HR.
HIT ANY KEY TO CONTINUE
HAS THERE BEEN ADDITIONAL INSULATING
MATERIALS ADDED OR DO YOU WISH TO
CONSIDER THEIR ADDITION? -- Y
FROM THE FOLLOWING SELECT THE ONE WHICH
BEST DESCRIBES YOUR WINDOWS:
     1.   LOOSE FITTING WITH OR WITHOUT
          WEATHERSTRIPPING
     2.   AVERAGE FIT WITH WEATHERSTRIPPING
     3.   AVERAGE FIT WITHOUT WEATHERSTRIP
ENTER THE NUMBER -- 2
WHAT IS THE TOTAL PERIMETER IN FEET OF
ALL WINDOWS?
?1152
SELECT HOW YOUR WINDOWS ARE SET FROM
THE FOLLOWING MENU:
     1.   MASONERY WALL, NOT CAULKED
     2.   MASONERY WALL, CAULKED
     3.   FRAME WALL, CAULKED OR NOT


ENTER NUMBER -- 2
THE INFILTRATION CALCULATIONS ARE BASED
ON THE FOLLOWING FORMULA
          Q=MCΔT


WHERE Q= HEAT LOSS IN BTU/HR; M=MASS OF
AIR;C=SPECIFIC HEAT; AND ΔT=CHANGE IN
TEMPERATURE
HIT ANY KEY TO CONTINUE
THE TOTAL HEAT LOSS DUE TO INFILTRATION
IS 29620 BTU/HR.
YOUR SAVINGS DUE TO THE UPGRADE ARE 77760 BTU/HR.
HIT ANY KEY TO CONTINUE
HAS THERE BEEN ADDITIONAL INSULATING
MATERIALS ADDED OR DO YOU WISH TO CONSIDER THEIR ADDITION? -- N
```

```
THE MENU BELOW WILL ENABLE YOU TO SELECT ANY SPECIFIC COMPONENT OR ALL OF
THEM.
HIT ANY KEY TO CONTINUE
```

M E N U

1. ROOF
2. FLOORS
3. INFILTRATION
4. WALLS
5. WINDOWS
6. END

```
SELECT OPTION BY NUMBER -- 4
THIS PART OF THE PROGRAM WILL ASK YOU
SEVERAL QUESTIONS ABOUT THE WALLS IN
BUILDING(S) IN QUESTION.
YOU SHOULD RESPOND WITH (Y) OR (N) TO
EACH QUESTION.  IN THE EVENT YOU HAVE
ADDED ADDITIONAL INSULATING MATERIALS
YOU WILL BE REQUIRED TO ENTER THE
CORRECT VALUE FROM THE TABLE WHICH WILL
APPEAR ON THE SCREEN.
HIT ANY KEY TO CONTINUE...
THE ANALYSIS IS BASED UPON THE FOLLOWING ASSUMPTIONS AS FAR AS THE BASIC
CONSTRUCTION IS CONCERNED.  IF YOU HAVE
ADDED OR PLAN TO ADD MATERIALS ABOVE THE BASIC WALL YOU MUST ENTER THE
R-VALUE FOR THESE ADDITIONS WHEN ASKED TO DO SO.

THE BASIC WALL IS COMPOSED OF A 4 IN.
COMMON BRICK; A NONREFLECTIVE AIR SPACE; AND A 4 IN. CINDER AGGREGATE BLOCK


THE FORMULA USED FOR THIS CALCULATION
IS
Q=UAΔT


HIT ANY KEY TO CONTINUE
PLEASE ENTER THE TOTAL SQUARE FOOTAGE
OF YOUR WALLS MINUS THE WINDOW AREA
?2574
```

```
IF YOU HAVE THE BASIC WALL THE HEAT LOSS IS EQUAL TO 37194 BTU/HR
HIT ANY KEY TO CONTINUE
HAVE YOU ADDED OR WOULD YOU LIKE TO KNOW THE EFFECT OF ADDING ADDITIONAL
INSULATING MATERIALS?  (Y) OR (N) -- Y
     REFLECTIVE AIR SPACE--1.75

     FILLED BLOCK CORES--1.5

     .5 IN GYPSUM WALL BOARD--.45

     POLYURETHANE FOAM--5.88

     UREAFORMALDEHYDE FOAM--4.0

     CELLULOSIC FIBER SPRAY--3.7

     PERLITE OR VERMICULITE SPRAY--1.67

ENTER THE TOTAL ADDITIONAL R-VALUE FROM
THE TABLE OR FROM VENDORS OF UNLISTED
MATERIALS TO GET A TOTAL WALL HEAT LOSS
?4.15
THE ADDITIONAL INSULATION YIELDS A HEAT
LOSS OF 16867 BTU/HR.
THIS IS A DIFFERENCE OF 20327 BTU/HR.


THE MENU BELOW WILL ENABLE YOU SELECT ANY SPECIFIC COMPONENT OR ALL OF THEM.
HIT ANY KEY TO CONTINUE
```

M E N U

1. ROOF
2. FLOORS
3. INFILTRATION
4. WALLS
5. WINDOWS
6. END

```
SELECT OPTION BY NUMBER -- 5
THIS PART OF THE PROGRAM WILL ASK YOU
SEVERAL QUESTIONS ABOUT THE WINDOWS IN
BUILDING(S) IN QUESTION.
YOU SHOULD RESPOND WITH (Y) OR (N) TO
EACH QUESTION.  THERE WILL BE A CHANCE
TO FIND OUT THE EFFECT OF UPGRADING
WINDOWS IN YOUR BUILDING.
APPEAR ON THE SCREEN.
HIT ANY KEY TO CONTINUE...
IN KEEPING WITH OUR CONVENTION OF USING
WINTER DESIGN CONDITIONS ALL DATA
WILL BE FOR WINTER DESIGN CONDITIONS.
IT WILL BE NECESSARY FOR YOU TO SUPPLY
CERTAIN INFORMATION ABOUT THE AREA OF
GLASS FACING IN VARIOUS DIRECTIONS
TYPE IN THE AREAS AS REQUESTED THEN
HIT THE (RETURN) KEY


WHAT IS THE WINDOW AREA FACING NORTH?
?0
WHAT IS THE AREA FACING NORTHEAST?
?432
WHAT IS THE AREA FACING EAST?
?0
WHAT IS THE AREA FACING SOUTHEAST?
?288
WHAT IS THE AREA FACING SOUTH?
?0
WHAT IS AREA FACING SOUTHWEST?
?432
WHAT IS THE AREA FACING WEST?
?0
WHAT IS THE AREA FACING NORTHWEST?
?0
YOU WILL NEED TO SUPPLY ONE OTHER BIT
OF DATA CONCERNING YOUR WINDOWS.
ARE YOUR WINDOWS OF SINGLE GLASS
CONSTRUCTION? -- Y
THE HEAT COEFFICIENT FORMULA WHICH WILL
BE USED WILL BE

                Q=UAΔT
```

WINTER DESIGN CONDITIONS WILL BE USED.

HIT ANY KEY TO CONTINUE
HEAT LOSS FROM YOUR SINGLE GLAZED
WINDOWS IS EQUAL TO 63359
BTU/HR.

HIT ANY KEY TO CONTINUE
WOULD YOU LIKE TO SEE THE LOSS SHOULD
YOU UPGRADE YOUR WINDOWS? -- Y
DO YOU HAVE STORM WINDOWS? -- Y
THE HEAT COEFFICIENT FORMULA WHICH WILL
BE USED WILL BE

$Q=UA\Delta T$

WINTER DESIGN CONDITIONS WILL BE USED.

HIT ANY KEY TO CONTINUE
HEAT LOSS FROM YOUR STORM SASHED
WINDOWS IS EQUAL TO 28800
BTU/HR.

HIT ANY KEY TO CONTINUE
WOULD YOU LIKE TO SEE THE LOSS SHOULD
YOU UPGRADE YOUR WINDOWS? -- N
DO YOU WISH TO SEE SAVINGS? -- Y
YOUR SAVINGS ARE EQUAL TO 34559 BTU/HR.
HIT ANY KEY TO CONTINUE
DECEMBER IS THE MONTH CHOSEN FOR THE
CALCULATIONS SINCE THIS IS THE LEAST
SOLAR HEAT GAIN MONTH.
DATA ASSUME SUNNY DAYS. IF THERE IS
CLOUD COVER ASSUME NO HEAT GAIN.
THE DESIGN LATITUDE IS 36 DEG NORTH.
THE TOTAL SOLAR HEAT GAIN FOR THE MONTH
OF DECEMBER IS EQUAL TO 182160 BTU/HR.

. . . . . .

M E N U

1. ROOF
2. FLOORS
3. INFILTRATION
4. WALLS
5. WINDOWS
6. END

SELECT OPTION BY NUMBER -- 6

THIS IS THE TALLY SECTION FOR THE
BUILDING ANALYSIS PROGRAM.
YOU MUST INDICATE YOUR RESPONSES BY
TYPING A (1) FOR YES OR A (2) FOR NO.
U S E N U M B E R S

DID YOU CONSIDER ROOF IMPROVEMENTS? -- 1

DID YOU CONSIDER FLOOR IMPROVEMENTS? -- 2

DID YOU CONSIDER INFILTRATION IMPROVE-
MENTS? -- 1

DID YOU CONSIDER WALL IMPROVEMENTS? -- 1

DID YOU CONSIDER WINDOW IMPROVEMENTS? -- 1
YOUR TOTAL BTU SAVINGS EQUALS 112324.17

THIS IS EQUAL TO A YEARLY BTU SAVINGS OF 983959729

DATA SHEET
Btu/Sq. Ft.

1. Percent instructional use space _____

   a. total square feet _____
   b. area devoted to instruction _____

2. Daily student costs _____ Professional _____ Nonprofessional _____

   a. central administrative costs _____
   b. total number of teachers _____
   c. number of teachers in school _____
   d. school service costs _____
   e. average teacher cost salary _____
   f. number of periods teacher teaches _____
   g. number of students in class _____
   h. transportation costs _____
   i. total number of students in system _____
   j. maintenance and operation costs _____
   k. number of students in school _____
   l. percent of instructional use space (see #1 above) _____

3. Energy costs (electric) _____

   a. enter up-to-date kwh costs in lines 3700-3900 (base is Duke Power Co. as of 1 Aug. 1982)
   b. kwh used _____
   c. billing demand (kw) _____

4. Btu-sq. ft. _____ Percent of national goal _____

   (average monthly use of:)
   a. electricity (kwh) _____
   b. natural gas (ccf) _____
   c. oil (gallons) _____
   d. coal (tons) _____
   e. LP gas (gallons) _____

(Fill in the lettered blanks before running the Btu/Sq. Ft. program.)

DATA SHEET
Btu/Sq. Ft.

1. Percent instructional use space 60.7
   a. total square feet 62,306
   b. area devoted to instruction 38,432 ft²
2. Daily student costs $1.19 Professional $1.06 Nonprofessional 0.13
   a. central administrative costs $31,000,000
   b. total number of teachers 3,894
   c. number of teachers in school 29
   d. school service costs $82,000
   e. average teacher cost salary $24,000
   f. number of periods teacher teaches 7
   g. number of students in class (K-3) = 26
   h. transportation costs $6,926,000
   i. total number of students in system 68,404
   j. maintenance and operation costs $15,498,000
   k. number of students in school 805
   l. percent of instructional use space (see #1 above) 6
3. Energy costs (electric) ~~$7351~~ 1551.77
   a. enter up-to-date kwh costs in lines 3700-3900 (base is Duke Power Co. as of 1 Aug. 1982)
   b. kwh used 36,495
   c. billing demand (kw) ~~5~~ 76
4. Btu-sq. ft. 64,384 Percent of national goal 85

   (average monthly use of:)
   a. electricity (kwh) 54,717
   b. natural gas (ccf) 0
   c. oil (gallons) 1069
   d. coal (tons) 0
   e. LP gas (gallons) 0

(Fill in the lettered blanks before running the Btu/Sq. Ft. program.)

BTU PER SQUARE FOOT

THIS PROGRAM IS DESIGNED FOR THE SCHOOL
ADMINISTRATOR WHO WANTS TO BECOME MORE
FAMILIAR WITH THE USE OF THE COMPUTER IN MANAGING THE FACILITIES AND IN
UNDERSTANDING THE BUDGET COSTS ASSOCIATED
WITH ENERGY USE.

USE OF THIS SERIES OF PROGRAMS
WILL NOT MAKE YOU AN EXPERT, BUT WILL
ENABLE YOU TO MAKE COMPUTER-ASSISTED
DECISIONS. THERE WILL BE A MENU
PRESENTED FOR YOU TO SELECT THE TOPIC
THAT YOU WISH TO EXPLORE. ALL YOU
NEED TO DO IS TO PRESS THE PROPER NUMBER FOR THAT PART OF THE PROGRAM TO
EXECUTE
HIT ANY KEY TO SEE MENU

M E N U
---

1. PERCENT INSTRUCTIONAL USE SPACE
2. TOTAL DAILY STUDENT COSTS
3. ENERGY COSTS
4. BTU'S PER SQUARE FOOT
5. END

PRESS THE NUMBER OF THE ROUTINE NEEDED
THIS ROUTINE FIGURES OUT THE PERCENT OF SPACE DEVOTED TO INSTRUCTIONAL USES
IF YOU ALREADY KNOW THIS FIGURE TYPE 'Y' TO RETURN
OTHERWISE HIT RETURN TO CONTINUE
YOU CAN USE THIS PROGRAM FOR THE ENTIRE SCHOOL OR FOR PARTICULAR CLASSROOMS.

WHAT IS THE AREA OF THE FACILITY (IN _____ SQUARE FEET)?
ENTER THE NUMBER, THEN TYPE RETURN -- 62306

HOW MANY SQUARE FEET ARE DEVOTED TO IN- STRUCTIONAL PURPOSES? ENTER THE
NUMBER
THEN HIT RETURN -- 38432
THE PERCENT OF INSTRUCTIONAL USE SPACE IS 61.682663

```
HIT RETURN TO CONTINUE

                M E N U
-----------------------------------------

1.    PERCENT INSTRUCTIONAL USE SPACE
2.    TOTAL DAILY STUDENT COSTS
3.    ENERGY COSTS
4.    BTU'S PER SQUARE FOOT
5.    END

PRESS THE NUMBER OF THE ROUTINE NEEDED
THIS ROUTINE FIGURES THE TOTAL DAILY
STUDENT COST.  IF YOU ALREADY KNOW THIS
TYPE Y TO RETURN TO MENU
OTHERWISE HIT RETURN TO CONTINUE
IN ORDER TO FIGURE COSTS ON A STUDENT  BASIS IT IS NECESSARY FOR YOU TO HAVE

     1.   CENTRAL ADMINISTRATIVE COSTS
     2.   TOTAL NUMBER OF TEACHERS
     3.   SCHOOL SERVICE COST
     4.   AVERAGE TEACHER COST SALARY
     5.   TRANSPORTATION COSTS
     6.   TOTAL NUMBER OF STUDENTS
     7.   NUMBER OF TEACHERS IN SCHOOL
     8.   MAINTENANCE AND OPERATING COSTS
     9.   % INSTRUCTIONAL USE SPACE
          (SEE MENU FOR HELP, IF NEEDED)
WHAT IS THE CENTRAL ADMINISTRATIVE COST (IN DOLLARS) ?31000000
WHAT IS THE TOTAL NUMBER OF TEACHERS IN THE SYSTEM ?3894
HOW MANY TEACHERS ARE IN THE SCHOOL?  29
WHAT IS THE SCHOOL SERVICE COST?  82000
WHAT IS THE AVERAGE TEACHER COST SALARY?  24000
HOW MANY PERIODS DOES THE TEACHER TEACH?  7
HOW MANY STUDENTS ARE IN THE CLASS?  26
HIT RETURN TO CONTINUE
THE COST FOR THE PROFESSIONAL SERVICES IS EQUAL TO 1.06192161 DOLLARS.

THIS, HOWEVER, IS NOT THE TOTAL COST TO THE SYSTEM.  NON-PROFESSIONAL
SERVICES
HIT ANY KEY TO CONTINUE.
WHAT ARE THE TRANSPORTATION COSTS?  6926000
WHAT IS THE TOTAL NUMBER OF STUDENTS?  68404
WHAT ARE THE MAINTENANCE AND OPERATION COSTS?  15498000
WHAT IS THE NUMBER OF STUDENTS IN THE SCHOOL?  805
IF THE INSTRUCTIONAL USE SPACE IS NOT KNOWN TYPE (HELP) AND RETURN,
OTHERWISE JUST HIT RETURN
?
WHAT IS THE PERCENT OF INSTRUCTIONAL USE SPACE?  .61
THE NON-PROFESSIONAL COSTS ARE EQUAL TO .133372043 DOLLARS.

HIT ANY KEY TO SEE THE TOTAL COSTS.

THE TOTAL COSTS PER DAY ARE 1.19529365 DOLLARS.
```

```
HIT RETURN TO CONTINUE

                    M E N U
-------------------------------------------

1.    PERCENT INSTRUCTIONAL USE SPACE
2.    TOTAL DAILY STUDENT COSTS
3.    ENERGY COSTS
4.    BTU'S PER SQUARE FOOT
5.    END


PRESS THE NUMBER OF THE ROUTINE NEEDED
THIS ROUTINE ASKS CERTAIN QUESTIONS CONCERNING ENERGY COSTS.  IT WILL BE
NECESSARY TO GET CURRENT COSTS FROM YOUR UTILITY COMPANY(IES)  BEFORE
PROCEEDING.


THE DATA IN THIS PROGRAM ARE FOR DUKE
POWER CO. AS OF 1 JANUARY 1982.  IF THE
RATES CHANGE OR YOU ARE SERVED BY SOME
OTHER COMPANY YOU MUST INSERT THE UP TO-DATE DATA IN LINES 3700-3900.

DO YOU WISH TO UPDATE? -- N

HIT ANY KEY TO CONTINUE

WHAT WAS THE KWH CONSUMPTION FOR THE ____ MONTH YOU WANT TO KNOW THE COST?
ENTER THE KWH'S AND THEN HIT (RETURN)  36495
WHAT IS YOUR BILLING DEMAND IN KILOWATTS
? 76
YOUR COST FOR THE MONTH IS APPROXIMATELY  $1551.77


HIT RETURN TO CONTINUE

                    M E N U
-------------------------------------------

1.    PERCENT INSTRUCTIONAL USE SPACE
2.    TOTAL DAILY STUDENT COSTS
3.    ENERGY COSTS
4.    BTU'S PER SQUARE FOOT
5.    END
```

ENERGY DATA

ELECTRIC (KWH).....3.4
OIL #2 (GAL).....138.69
NAT. GAS (CCF).....103.0
COAL (TONS).....24500.0
LP GAS (GAL).....95.475

HIT ANY KEY TO CONTINUE
TYPE THE NAME OF THE SCHOOL THEN HIT RETURN -- NEWELL ELEM.

WHAT WAS YOUR TOTAL KWH USE? YOU MUST USE MONTHLY CONSUMPTION DATA

?54717
WHAT WAS YOUR CONSUMPTION OF NATURAL GAS IN HUNDREDS OF CUBIC FEET
(CCF/MONTH)? 0
WHAT WAS YOUR CONSUMPTION OF OIL IN GALLONS? 1069
WHAT WAS YOUR CONSUMPTION OF COAL (IN ____ ANY) IN TONS? 0
WHAT WAS YOUR CONSUMPTION OF LP GAS (IN GALLONS)? 0
ONE LAST BIT OF DATA NEEDED IS THE TOTAL SQUARE FOOTAGE OF THE BUILDING.
62306

YOUR MONTHLY BTU USE IS 334297000

THIS MAKES YOUR YEARLY CONSUMPTION = 4.011564E+09 BTU'S

ON A SQUARE FOOT BASIS YOU HAVE USED 64384 BTUS/SQUARE FOOT.

THE NATIONAL GOAL IS TO USE ONLY 55000 BTU'S/SQ.FT.

THIS MEANS THAT YOU HAVE ACHIEVED ABOUT 85% OF THE NATIONAL GOAL.

DO YOU HAVE OTHER ENERGY COSTS (Y/N)? -- N

M E N U

1. PERCENT INSTRUCTIONAL USE SPACE
2. TOTAL DAILY STUDENT COSTS
3. ENERGY COSTS
4. BTU'S PER SQUARE FOOT
5. END

PRESS THE NUMBER OF THE ROUTINE NEEDED

THANK YOU

DATA SHEET
Payback

1. Dollar savings _____

   a. cost — electricity (kwh) _____ oil (gal) _____
   — natural gas (ccf) _____ coal (ton) _____
   — LP gas (gal) _____

   b. Btu saved — electricity _____ oil _____
   — natural gas _____ coal _____
   — LP gas _____

2. Debt service constant _____

   a. interest rate _____
   b. number of years of useful life _____

3. Amortization costs for added materials _____

   a. difference in capital costs _____

4. Annual O & M savings _____ Benefit/cost ratio _____

   a. yearly O & M for system A _____
   b. yearly O & M for system B _____

5. Payback time for investment _____

6. Present worth of savings _____

7. Fuel savings with rising costs _____

   a. annual fuel costs system A _____
   b. annual fuel costs system B _____

8. Total savings over payback _____

(Fill in the lettered blanks before running the Payback program.)

DATA SHEET
Payback

1. Dollar savings $3,417

   a. cost — electricity (kwh) .05 — oil (gal) $1.03
   — natural gas (ccf) _____ — coal (ton) _____
   — LP gas (gal) _____

   b. Btu saved — electricity _____ — oil 460,183,139
   — natural gas _____ — coal _____
   — LP gas _____

2. Debt service constant .102

   a. interest rate .095

   b. number of years of useful life 30

3. Amortization costs for added materials $2135

   a. difference in capital costs $21,000

4. Annual O & M savings $3,417 — Benefit/cost ratio 1.6

   a. yearly O & M for system A $13,316

   b. yearly O & M for system B $9,899

5. Payback time for investment 9.66 yrs

6. Present worth of savings $12,605

7. Fuel savings with rising costs $73,103

   a. annual fuel costs system A $13,316

   b. annual fuel costs system B $9,899

8. Total savings over payback $52,103

(Fill in the lettered blanks before running the Payback program.)

```
THIS PROGRAM IS THE KEY ONE FOR
DETERMINING THE NET EFFECT OF ANY
ADDITIONS TO YOUR BUILDINGS.
IN ORDER TO USE THIS PROGRAM WITH THE
GREATEST BENEFIT IT WILL BE NECESSARY
THAT YOU HAVE COMPLETED THE OTHER PARTS
OF THE PACKAGE AND HAVE THE COMPLETED
DATA SHEETS BEFORE YOU.
THIS PROGRAM WILL ANALYSE THE CURRENT
SAVINGS, LOOK AT LONG TERM SAVINGS AND
FIGURE PAYBACK TIME.
THIS WILL BE DONE IN A GENERAL MANNER
AND BE APPLICABLE TO ANY ENERGY SOURCE.

HIT ANY KEY TO CONTINUE
IN ORDER TO FIGURE COSTS PROPERLY IT
WILL BE NECESSARY TO GET SOME DATA
CONCERNING YOUR FUEL COSTS.
IF YOU HAVE MORE THAN ONE TYPE OF FUEL
IT WILL BE NECESSARY TO FIGURE EACH.
RESPOND TO THE QUESTIONS AND THE PRO-
GRAM WILL DO THE REST.
IN THE EVENT THAT YOU DO NOT HAVE THE
SOURCE LISTED HIT '0' AND (RETURN).

WHAT IS YOUR COST PER KILOWATT-HOUR FOR
ELECTRICITY?.05
WHAT IS THE COST PER HUNDRED CUBIC FEET
OF NATURAL GAS?0
WHAT IS THE COST PER GALLON OF OIL?
?1.03
WHAT IS THE COST PER TON FOR COAL?  0
WHAT IS THE COST PER GALLON FOR LP GAS?0

HOW MANY BTU OF ELECTRICITY ARE SAVED?
?0
HOW MANY BTU OF NATURAL GAS ARE SAVED?
?0
HOW MANY BTU OF OIL ARE SAVED?
?460,183,139
HOW MANY BTU OF COAL ARE SAVED?
?0
HOW MANY BTU OF LP GAS ARE SAVED?
?0
YOUR TOTAL SAVINGS ARE $ 3,417
HIT ANY KEY TO CONTINUE
WHAT IS YOUR INTEREST RATE ?.095
WHAT IS THE USEFUL LIFE OF THE ADDITION
WE SHALL ASSUME FINANCING FOR THE
DURATION.
?30
YOUR DEBT SERVICE CONSTANT IS .101680584.
WHAT IS THE DIFFERENCE IN CAPITAL COSTS OF THE TWO STRUCTURES ? (DOLLARS)
21,000
```

```
YOUR AMORTIZATION COST FOR THE ADDED
INVESTMENT IS $ 2135
WHAT IS THE YEARLY O&M COST FOR SYSTEM A?13316
WHAT IS THE YEARLY O&M COST FOR SYSTEM B?9899
THE ANNUAL OPERATION AND MAINTENANCE
SAVING IS $ 3417
YOUR COST BENEFIT RATIO IS  1.6
FOR THIS EXAMPLE IT IS ASSUMED THAT THE ENTIRE O&M SAVING WILL BE USED TO
PAY BACK THE LOAN.
THE NUMBER OF YEARS TO PAY IS 9.66.


IN FIGURING THE TOTAL LONG TERM SAVINGS
 IT IS NECESSARY TO CONSIDER ANNUAL O&M AS WELL AS ADDITIONAL AMORTIZATION
COST FOR YOUR BUILDINGS THIS AMOUNTS TO $ 12034
THE PRESENT WORTH OF THE 30-YEAR DIF-
FERENCE IS $ 12605
FOR THIS PART OF THE PROGRAM IT IS NECESSARY TO KNOW ANNUAL FUEL COSTS.
WHAT IS THE ANNUAL FUEL COST FOR NUMBER ONE?13316
WHAT IS THE COST FOR BUILDING TWO?9899
AN AVERAGE COST INCREASE OF 7% IS USED FOR FUEL COST.
ENERGY COSTS FOR BUILDING ONE ARE $ 284883 FOR THE 30 YEARS
ENERGY COSTS FOR BUILDING TWO ARE $ 211780 FOR THE SAME PERIOD.
THIS RESULTS IN AN ENERGY SAVINGS OF $ 73103.
THE LIFETIME MAINTENANCE COSTS FOR
BUILDING ONE ARE $ 0
THE LIFETIME COSTS FOR BUILDING TWO ARE $ 0
THIS RESULTS IN A MAINTENANCE SAVINGS OF $ 0
IN SUMMARY THE SAVINGS AND COSTS WHICH CAN BE ATTRIBUTED TO THE MORE
EFFICIENT

ENERGY SAVINGS......$ 73103

MAINTENANCE SAVINGS.$ 0

ORIGINAL COST.......($ 21000)
WHAT THIS AMOUNTS TO IS A 'PRESENT WORTH' SAVINGS FOR THE 30-YEAR PAYBACK
FOR BUILDING TWO...THE MORE ENERGY EFFICIENT STRUCTURE OF $ 52103.


DO YOU HAVE OTHER BUILDINGS YOU WISH TO COMPARE ?(Y/N)N
```

APPENDIX B

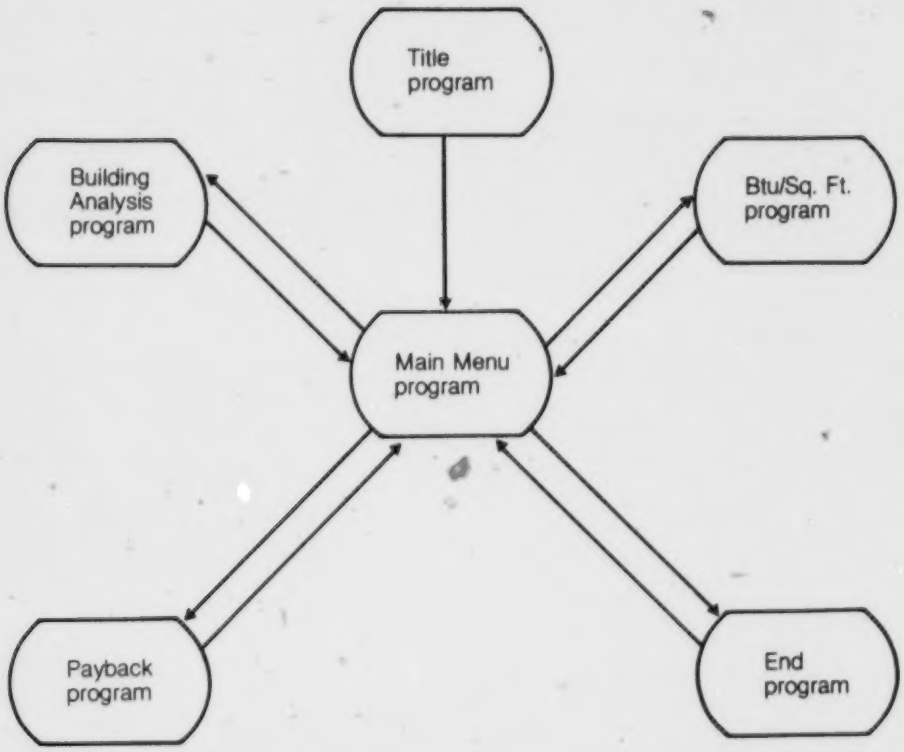
PROGRAM LISTINGS

The user of the SRDAS must enter the programs into the computer which the school or school system uses. The specific program lines which must be entered are contained in this appendix along with flow charts which outline the logical sequence of the various subprograms. SRDAS is made up of three primary and three secondary subprograms. Each of the subprograms must be typed separately and then saved onto magnetic tape or magnetic disc. Once the programs have been entered and saved the user may proceed with whatever analyses are desired.

Within the programs are explanatory notes which do not facilitate the execution of the program. These notes are called "REM" statements. Their purpose is to make a written program easier for a human to understand the process which the computer uses to solve a problem. If the computer has a memory limitation, these statements may be left out when the program is typed.

The sequence of subprograms within this appendix is the same sequence which was used in chapter IV and in the sample run described in appendix A. The subprograms are identified with a title at the beginning of the listing. The flow diagrams are identified with a figure number and legend explaining the diagram.

Figure 58
SRDAS



This is the flow chart for the entire package of subprograms in SRDAS. The Title program leads the user into the Main Menu program. From the Main Menu any of the four alternatives can be selected.

Title Subprogram Listing

```
5     TEXT : HOME
6     HGR
10     PRINT "BLOAD SRDAS"
50     VTAB (22)
87     PRINT : PRINT : INVERSE
88     REM  GET RESPONSE TO CONTINUE
90     PRINT "          HIT ANY KEY TO CONTINUE          ": GET K$
91     NORMAL
100    D$ =  CHR$ (4): REM  CNTRL-D
101     PRINT D$;"RUN PRIMARY MENU"
200     REM  COPYRIGHT STEPHEN CANIPE,1982.
```

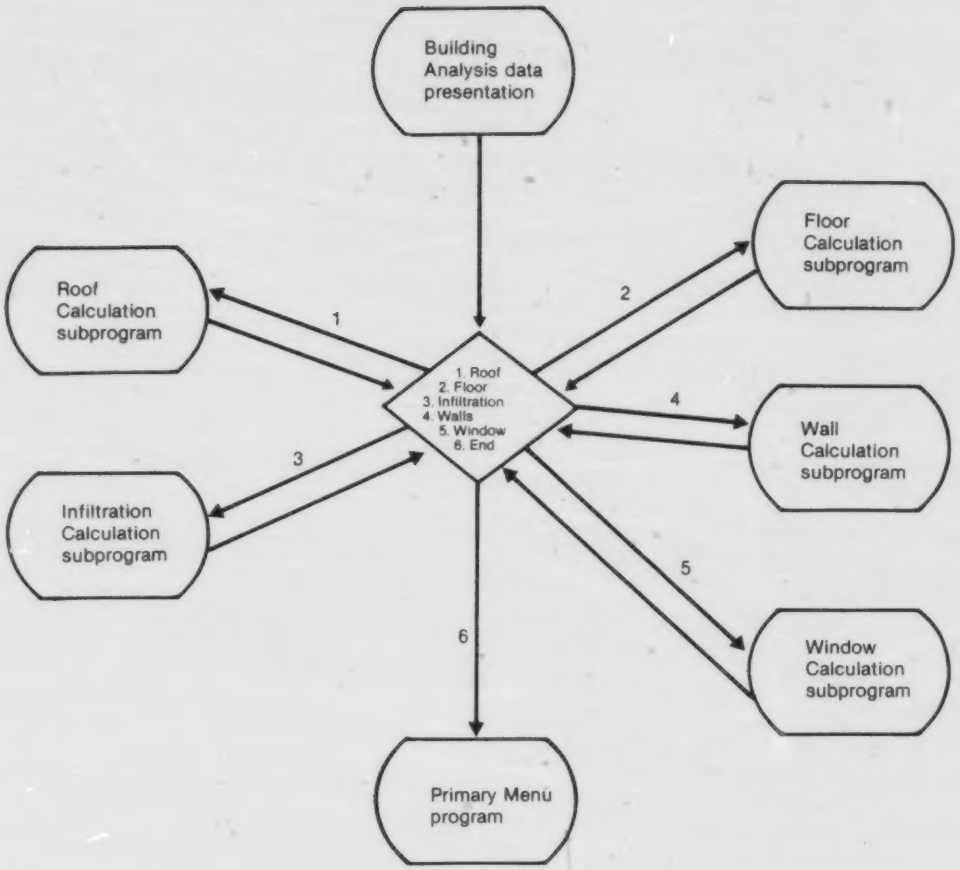
Main Menu Subprogram Listing

```
4    REM SLOW DOWN FOR EASY READIN
       G
5    SPEED= 200
10    TEXT : HOME
20   PRINT : PRINT : PRINT : PRINT
      "THIS PROGRAM IS DESIGNED TO
       HELP SCHOOL ADMINISTRATORS D
      ETERMINE THE ENERGY USE,"
22   PRINT "NEEDED ENERGY IMPROVEM
      ENTS, AND PAYBACK PERIODS FO
      R THEIR SCHOOLS."
30   PRINT : PRINT : PRINT : PRINT
      : INVERSE : PRINT "THIS PROG
      RAM IS PART OF A DOCTORAL "
31   PRINT "DISSERTATION IN SCHOOL
       ADMINISTRATION   FROM DUKE
      UNIVERSITY"
32   PRINT : PRINT
33   FLASH : PRINT "PREPARED BY ST
      EPHEN L. CANIPE": NORMAL
34   PRINT
35   PRINT "        DECEMBER, 1981
      "
38   PRINT : PRINT
39   REM  SLOW DOWN AND GET RESPON
      SE TO CONTINUE
40   SPEED= 198: INVERSE : PRINT "
             HIT ANY KEY TO CO
      NTINUE : NORMAL : PRINT : GET
      K$
50   HOME : SPEED= 255
57   REM CLEAR SCREEN AND TRAP ER
      RORS
58   HOME : ONERR GOTO 60
60   VTAB (5): HTAB (18): INVERSE
      : PRINT "M E N U"
61   NORMAL
70   PRINT : PRINT "CHOOSE FROM TH
      E MENU THE OPERATION THAT YO
      U WOULD LIKE TO SEE."
73   PRINT "SELECT BY THE NUMBER,
      PLEASE!"
80   HTAB (5): PRINT "1.  BUILDING
       ANALYSIS"
85   PRINT : HTAB (5): PRINT "2.
      BTU/SQ. FT."
100  PRINT : HTAB (5): PRINT "3.
      FIGURE PAYBACK PERIOD"
120  PRINT : HTAB (5): PRINT "4.
      END"
```

```
125  GET A: IF A < 1 OR A > 4 THEN
      GOTO 58
128  D$ =  CHR$ (4): REM  CNTRL-D
130  IF A = 1 THEN PRINT D$;"RUN
      BUILDING ANALYSIS"
135  IF A = 2 THEN PRINT D$;"RUN
      BTU/SQ. FT."
145  IF A = 3 THEN PRINT D$;"RUN
      PAYBACK"
150  IF A = 4 THEN PRINT D$;"RUN
      END"
63000  REM COPYRIGHT-STEPHEN CAN
     IPE-1982 MATTHEWS NC 28105
```

Figure 59

Building Analysis



This flow chart represents the possible decisions which can be made from the Building Analysis subprogram. An *End* selection from the menu returns the user to the Primary Menu program.

Figure 60

Roof Subprogram

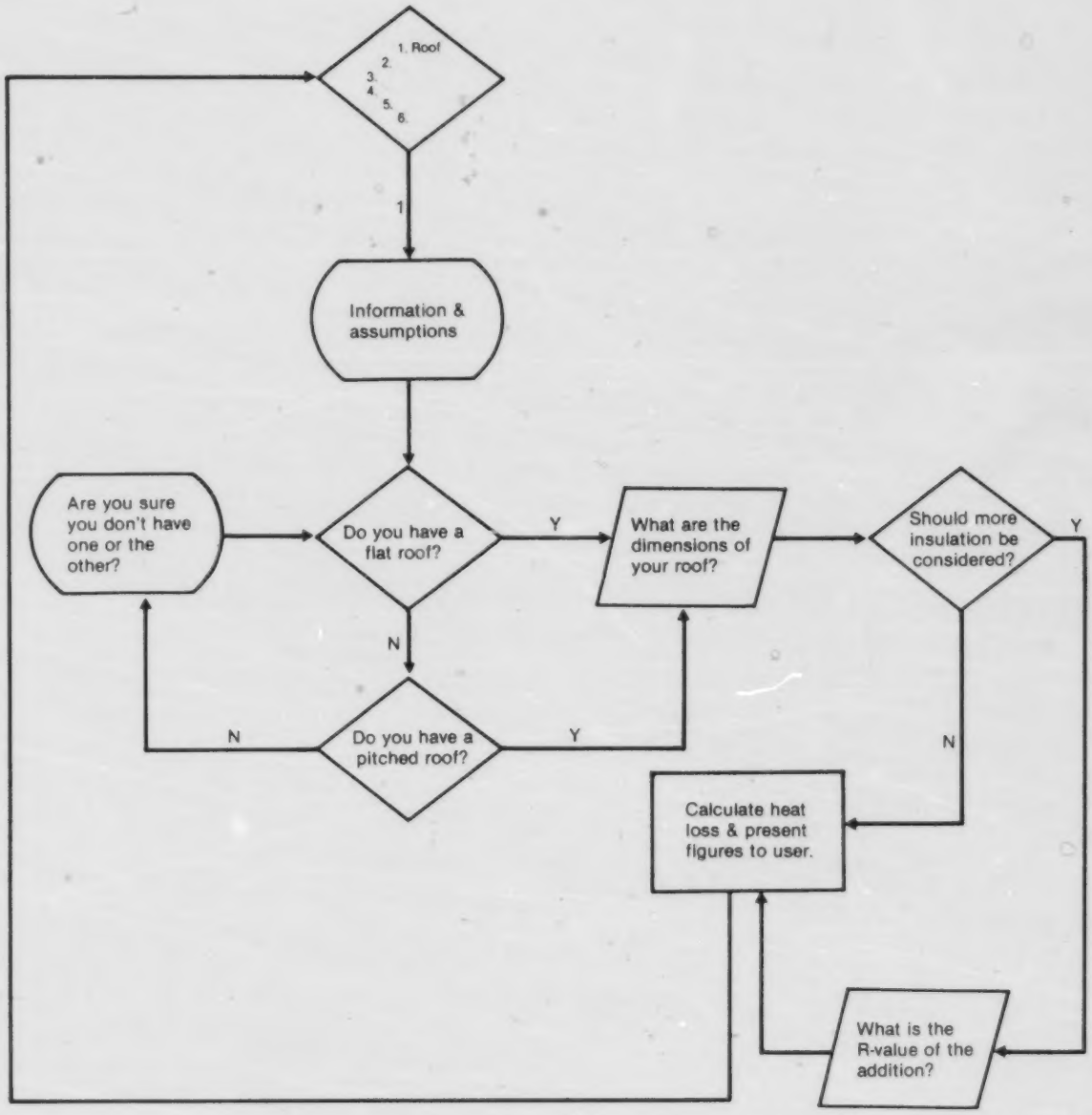


Figure 61

Floor Subprogram

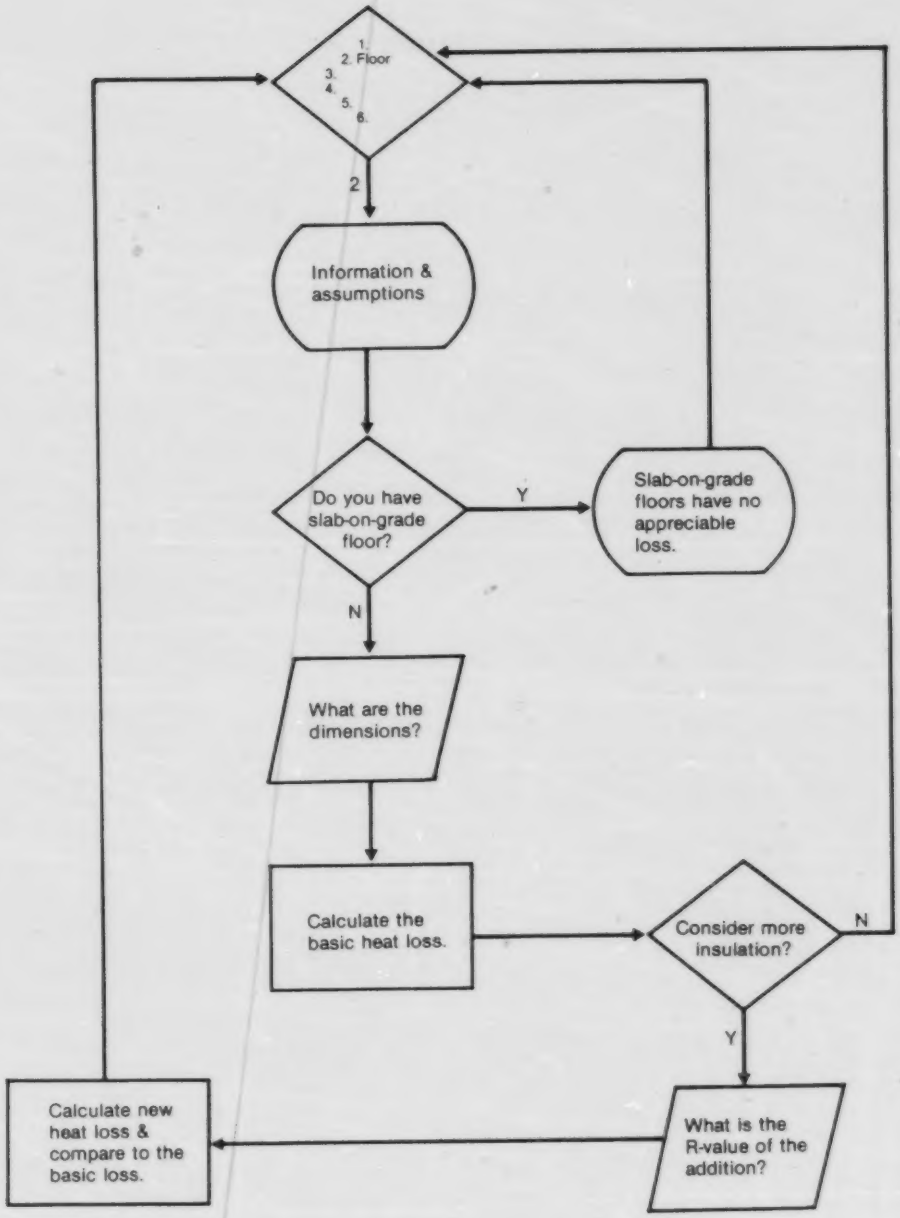


Figure 62

Infiltration Subprogram

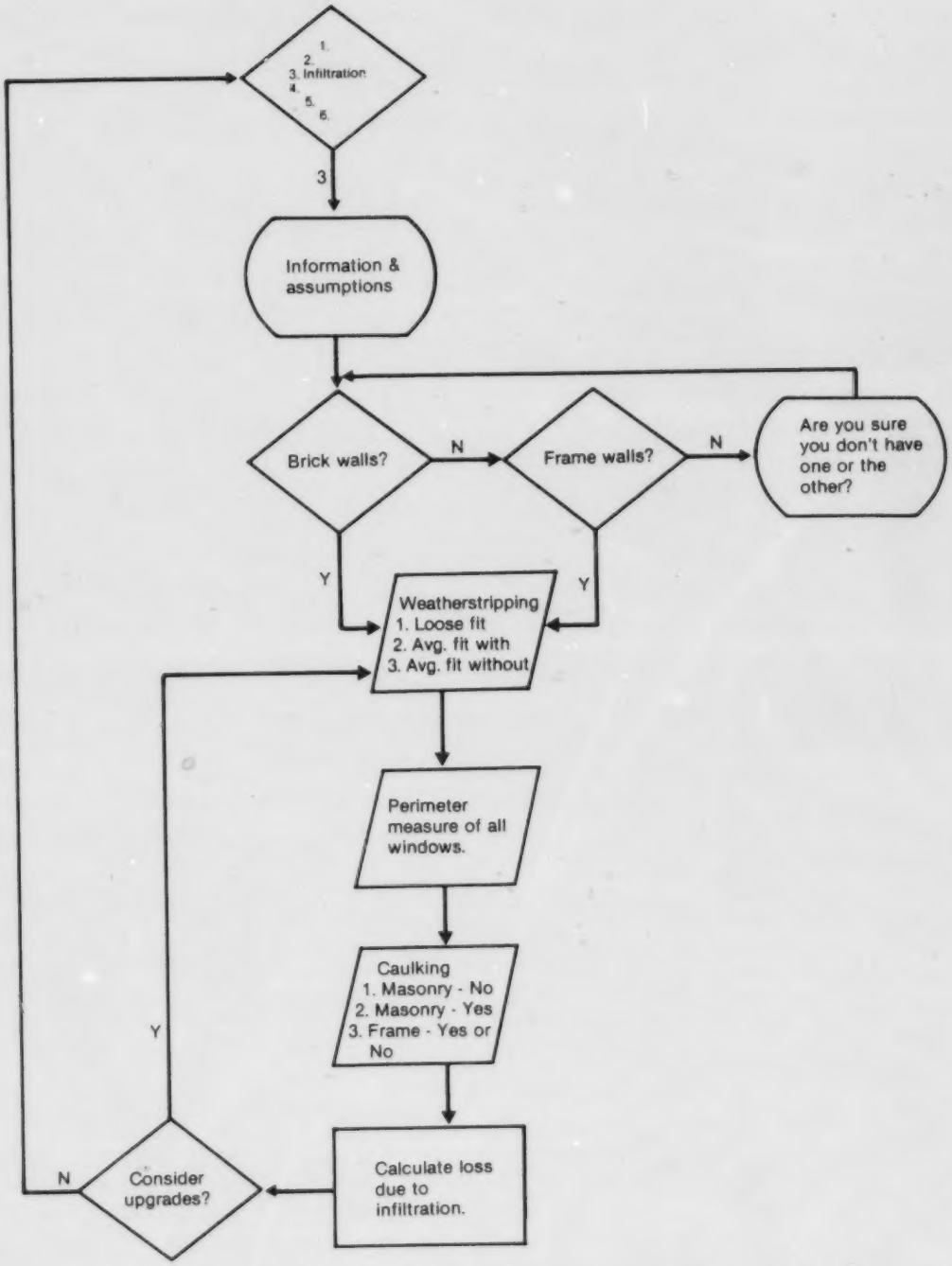


Figure 63

Walls Subprogram

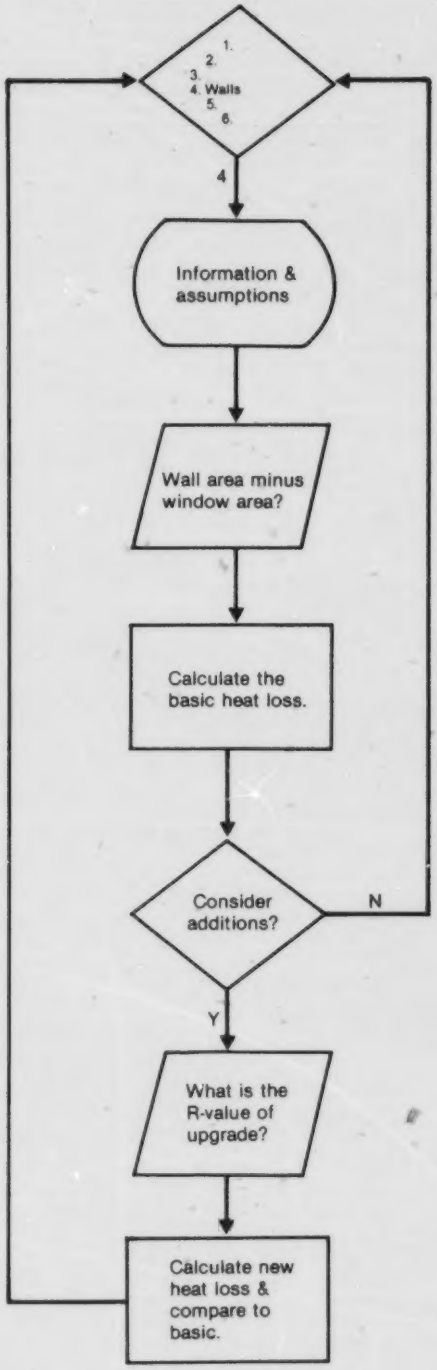


Figure 64

Windows Subprogram

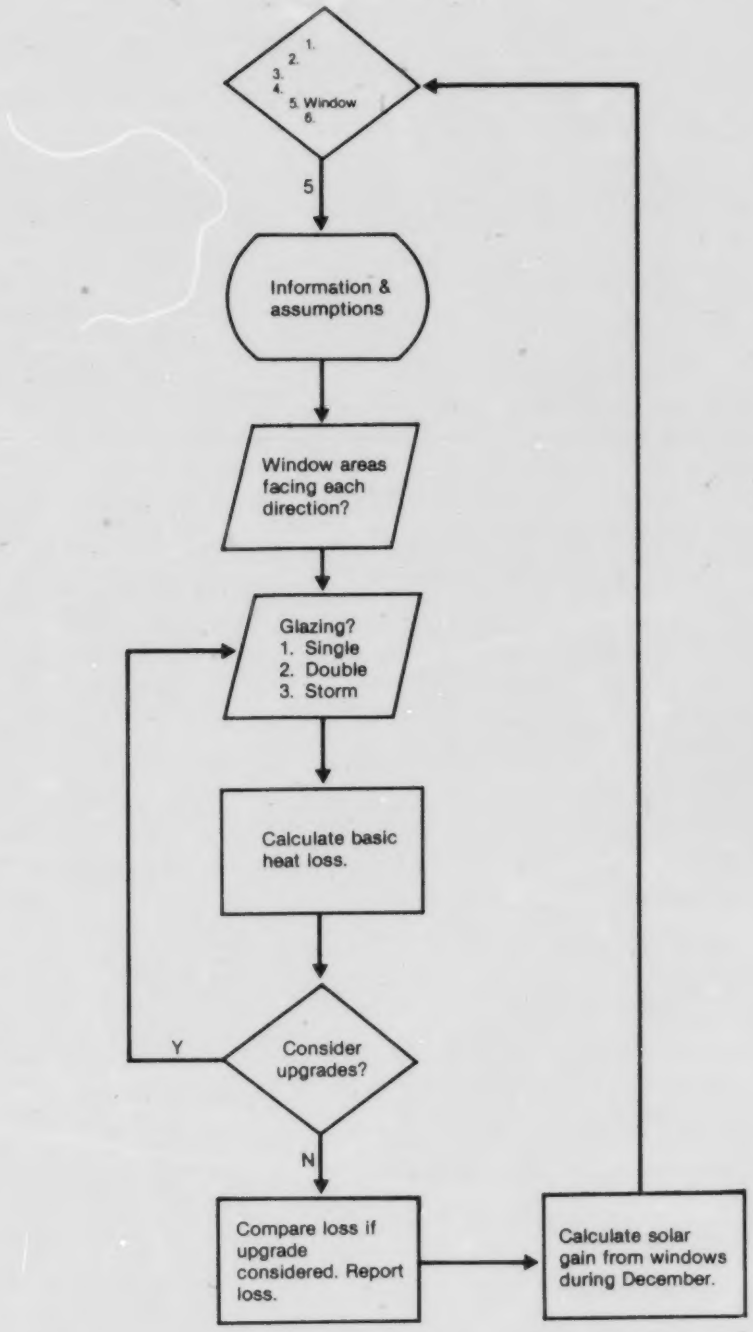
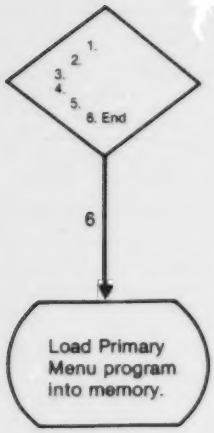


Figure 65

End Subprogram



Building Analysis Subprogram Listing

```
4    HOME : PRINT : PRINT : PRINT :
       PRINT : PRINT : PRINT : INVERSE
      : PRINT "
                              ": NORMAL

5    PRINT : VTAB (10): PRINT "B U
      I L D I N G   A N A L Y S I
      S "
10   PRINT "======================
     ============="
15   PRINT : PRINT : PRINT "THIS P
      ROGRAM WILL EXAMINE VARIOUS
      ": PRINT "ASPECTS OF SCHOOL
      HOUSE DESIGN AND WILL"
20   PRINT "DETERMINE THE BTU LOSS
      (OR GAIN) FROM ": PRINT "FRO
      M THE VARIOUS COMPONENTS"
21   PRINT
24   INVERSE : PRINT "

     ": NORMAL
25   ONERR GOTO 39
30   REM MENU FOR ANALYSIS COMPON
      ENTS
35   PRINT : PRINT : PRINT : PRINT
      : PRINT "THE MENU BELOW WILL
      ENABLE YOU SELECT    ANY SPE
      CIFIC COMPONENT OR ALL OF TH
      EM."
38   PRINT "HIT ANY KEY TO CONTINU
      E"
39   GET A$: HOME : FLASH
40   VTAB (5): PRINT "
                                   ":
       NORMAL
44   VTAB (7)
45   PRINT  TAB( 17)"M E N U "
47   PRINT : PRINT
50   PRINT  TAB( 7)"1.  ROOF"
55   PRINT  TAB( 7)"2.  FLOORS"
60   PRINT  TAB( 7)"3.  INFILTRATI
      ON"
65   PRINT  TAB( 7)"4.  WALLS"
70   PRINT  TAB( 7)"5.  WINDOWS"
75   PRINT  TAB( 7)"6.  END"
85   PRINT : PRINT : PRINT : INVERSE
      : PRINT "
                              ": NORMAL
```

```
90   PRINT : PRINT "SELECT OPTION
     BY NUMBER": GET A: IF A < 1 OR
     A > 7 THEN PRINT "": GOTO 9
     0
95   REM  SET UP SUBROUTINES
100   IF A = 1 THEN  GOSUB 1000
105   IF A = 2 THEN  GOSUB 2000
110   IF A - 3 THEN  GOSUB 3000
115   IF A = 4 THEN  GOSUB 4000
120   IF A = 5 THEN  GOSUB 5000
125   IF A - 6 THEN  GOSUB 6000
127   LET D$ =  CHR$ (4): REM  CNT
     RL-D
135   GOTO 30
1000   REM  CEILING ROUTINE
1001   LET Q = 0: LET Q1 = 0: LET
     Q2 = 0: LET R = 0: LET A = 0
     : LET B = 0: LET C = 0: REM
      ZERO ALL VARIABLES
1005  HOME : VTAB (4): PRINT "THI
     S PART OF THE PROGRAM WILL A
     SK YOU": PRINT "SEVERAL QUES
     TIONS ABOUT THE ROOF ON THE"

1010  PRINT "BUILDING(S) IN QUEST
     ION.": PRINT : PRINT "YOU SH
     OULD RESPOND WITH (Y) OR (N)
      TO"
1015  PRINT "EACH QUESTION.  IN T
     HE EVENT YOU HAVE": PRINT "A
     DDED ADDITIONAL INSULATING M
     ATERIALS"
1020   PRINT "YOU WILL BE REQUIRED
      TO TYPE IN THE ": PRINT "CO
      RRECT VALUE FROM THE TABLE W
      HICH WILL"
1025  PRINT "APPEAR ON THE SCREEN
     "
1030  VTAB (20): INVERSE : PRINT
     "HIT ANY KEY TO CONTINUE..."
     : NORMAL : GET A$
1035  HOME
1040   PRINT "DO YOU HAVE A FLAT,
     BUILT-UP ROOF?(Y/N)": GET A$
     : IF A$ = "Y" THEN  GOTO 150
     0
1043  IF A$ <  > "N" THEN  GOTO 1
     040
1045  PRINT "DO YOU HAVE A PITCHE
     D ROOF ?(Y/N)": GET A$: IF A
     $ = "Y" THEN  GOTO 1100
1046  IF A$ <  > "N" THEN  GOTO 1
     045
```

```
1048  REM  GET AN ANSWER FOR ROOF
      TYPE
1049  FLASH : PRINT : PRINT : PRINT
      " # # # # # # # # # # # # #
      # # # # # # #": PRINT : PRINT
      : NORMAL
1050  PRINT "ARE YOU REALLY SURE
      THAT YOU DON'T HAVE": PRINT
      "ONE OR THE OTHER KIND OF RO
      OF?"
1051  FOR PAUSE = 1 TO 2500: NEXT
      PAUSE: GOTO 1035
1100  REM  INSULATING MATERIALS--
      PITCHED ROOF
1101  HOME
1105  PRINT "PITCHED OR SLOPED RO
      OFS HAVE BEEN MAKING";: PRINT
      "A COME BACK IN RECENT YEARS
      ."
1110  PRINT "MOST OF THE INSULATI
      NG MATERIALS WHICH ": PRINT
      "CAN BE USED ARE FOUND IN TH
      E CHART BELOW"
1115  PRINT "ALL THAT YOU HAVE TO
       DO IS TO ADD THE R-";: PRINT
       "VALUES FROM THE FOLLOWING T
       ABLE "
1120  PRINT "THAT YOU HAVE ADDED
      OR WISH TO ADD TO ": PRINT "
      YOUR ROOF"
1122  VTAB (20): INVERSE : PRINT
      "HIT ANY KEY TO CONTINUE ":
      GET A$
1124  HOME : VTAB (7)
1125  PRINT "I N S U L A T I N G
       M A T E R I A L S": NORMAL

1126  PRINT "==================
      ==================": PRINT
1130  PRINT  TAB(2)"A. BATT/BLAN
      KET=3.14 R/INCH"
1135  PRINT  TAB( 2)"B. EXPANDED
      POLYSTYRENE=4.5 R/INCH"
1140  PRINT  TAB( 2)"C. CELLULAR
      POLYURETHANE=6.25 R/INCH"
1145  PRINT  TAB( 2)"D. POLISOCYA
      NURATE=7.2R/INCH"
1150  PRINT  TAB( 2)"E. LOOSE MIN
      ERAL FIBER-2.2R/INCH"
1153  PRINT  TAB( 2)"F. ACOUSTIC
      TILE-2.7 R/INCH"
```

```
1160  PRINT : FLASH : PRINT "NUMB
      ERS ARE APPROXIMATE ": PRINT
      : NORMAL : PRINT "CONSULT TH
      E VENDOR FOR EXACT R VALUES
      "
1165  VTAB (18): PRINT " HIT ANY
      KEY TO CONTINUE  ": GET A$
1170  LET Q =  INT (Q)
1171  REM ASHRAE FUNDAMENTALS VO
      LUMN
1172  REM  CHAPTER 23,PAGE25,TABL
      E 4K
1173  REM  GET INFO ABOUT SIZE OF
       ROOF
1175  INPUT "WHAT ARE THE DIMENSI
      ONS OF YOUR ROOF ?";A,B
1176  LET Q = .206 * A * B * 50
1180  PRINT "IF THERE HAS BEEN NO
       ADDITIONAL INSULA-": PRINT
      "TION ADDED THE HEAT LOSS EQ
      UALS ";Q;"BTU/HR."
1185  PRINT "DO YOU HAVE OR DO YO
      U WISH TO CONSIDER": PRINT "
      THE EFFECT OF A SUSPENDED CE
      ILING? (Y/N)": GET C$: IF C$
      = "N" THEN  GOTO 1190
1187  CI = 1: PRINT "FOR ALL AIR S
       PACES OVER 3.5 IN. THE R-": PRINT
       "VALUE IS CONSIDERED TO BE 1
       .0"
1189  PRINT "REMEMBER TO ADD THIS
       TO THE OTHER R-": PRINT "VA
      LUES THAT YOU WISH TO CONSID
      ER.": PRINT "REMEMBER TO INC
      LUDE THE VALUE FOR TILES.": PRINT
      "": PRINT
1190  PRINT : PRINT "ENTER THE TO
      TAL R-VALUE OF MATERIALS ": PRINT
      "FROM THE TABLE ABOVE ": INPUT
      R
1191  REM  DO CALCULATIONS FOR Q/
      A=UΔT
1192 Q1 = (1 / (4.69 + R)) * A *
      B * 50
1193 Q1 =  INT (Q1)
1195  HOME : VTAB (15)
1199  PRINT "THE HEAT LOSS WITH T
      HIS INSULATION IS ";Q1;" BTU
      /HR."
1200 Q2 = Q - Q1:Q2 -  INT (Q2)
1201  PRINT "THIS IS A SAVINGS OF
       ";Q2;" BTU/HR."
1205  VTAB (20): INVERSE : PRINT
      "H I T  A N Y  K E Y ": NORMAL
```

```
1206  GET A$
1210  GOTO 39
1500  REM  CALCULATIONS WITH BUIL
     T-UP ROOF
1501  HOME
1505  PRINT : PRINT : PRINT : PRINT
     "THE CALCULATIONS DONE IN TH
     IS SECTION ": PRINT "ARE BAS
     ED ON THE FORMULA:"
1509  PRINT : PRINT : PRINT : PRINT

1510  PRINT "          Q/A=UΔT"
1515  PRINT : PRINT "WHERE Q= HEA
     T TRANSFER; A= AREA": PRINT
     "U=HEAT TRANSFER COEFFICIENT
     ; AND ΔT= "
1520  PRINT "CHANGE IN TEMPERATUR
     E."
1525  PRINT : PRINT : PRINT "THE
     DESIGN TEMPERATURE USED IS 1
     8 DEG-F"
1526  PRINT "AT THE WINTER CONDIT
     IONS AND 93 DEG-F ": PRINT "
     AT THE SUMMER CONDITIONS."
1527  PRINT "SINCE THE WINTER CON
     DITIONS ARE MOST": PRINT "SE
     VERE THEY WILL SERVE AS THE
     BASIS FOR": PRINT "CALCULATI
     ONS."
1528  INVERSE : SPEED= 100: PRINT
     "    HIT  ANY  KEY  TO  CONT
     INUE ": NORMAL : SPEED= 255:
      GET A$
1530  REM  ROOF STRUCTURE IS BASE
     D ON THE 1981
1531  REM  ASHRAE FUNDAMENTALS VO
     LUMN
1532  REM  CHAPT.23.24;TABLE 4J;E
     X.1
1535  REM  GET INFO. ABOUT ROOF S
     IZE
1540  INPUT "WHAT ARE THE DIMENSI
     ONS OF YOUR ROOF ?";A,B
1542  PRINT : PRINT "DO YOU HAVE
     A SUSPENDED CEILING? (Y/N)":
      GET A$: IF A$ = "Y" THEN  GOSUB
     1900: GOTO 1550
1545  PRINT "HAVE THERE BEEN ADDI
     TIONAL INSULATING": PRINT "M
     ATERIALS ADDED TO YOUR ROOF?
     (Y) OR (N)": GET A$
```

```
1547  LET Q = .153 * A * B * 50
1548  IF A$ = "Y" THEN  GOTO 1600

1550  PRINT "DO YOU WISH TO FIND
      OUT WHAT THE EFFECT": PRINT
      "OF PROPOSED ADDITIONS WILL
      MAKE?": GET A$
1554  LET Q =  INT (Q)
1555  IF A$ = "Y" THEN  GOTO 1600

1559  HOME
1560  VTAB (10): PRINT "YOUR HEAT
       LOSS FROM THE ROOF IS ";Q;"
      BTU/HR"
1570  GOTO 1700
1600  REM  ADDED ROOF MATERIALS
1601  GOSUB 1800
1602  VTAB (20): INVERSE : PRINT
      "HIT ANY KEY TO CONTINUE ": NORMAL : GET A$
1604  HOME
1605  VTAB (15): INPUT "WHAT IS T
      HE R-VALUE OF THE MATERIAL ?
       ";C
1610  LET Q1 = (1 / (6.34 + C)) *
      A * B * 50
1612  LET Q1 =  INT (Q1)
1615  PRINT "THE HEAT LOSS WITH T
      HIS AMOUNT OF INSULATION IS
      ";Q1;" BTU/HR."
1620  PRINT "THIS IS A SAVINGS OF
      ";Q - Q1;" BTU/HR."
1700  PRINT "HIT ANY KEY TO CONTI
      NUE": GET A$
1701  GOTO 39
1800  REM  ROOF ADDITIONS
1801  HOME
1805  PRINT "ROOF INSUALTION IS P
      REFORMED AND IS USED":; PRINT
      "ABOVE THE METAL DECK."
1810  PRINT "DIFFERENT MANUFACTUR
      ERS HAVE DIFFERENT": PRINT "
      INSULATING PROPERTIES IN THE
      IR ADDITIONS"
1820  PRINT : PRINT : PRINT "IT W
      ILL BE NECESSARY TO CONSULT
      A ": PRINT "SPECIFIC MANUFAC
      TURER TO DETERMINE R-"
1825  PRINT "VALUES. (THE RANGE I
      S 2.7 TO 20.)"
1826  PRINT ""
```

```
1827  PRINT "IF YOU HAVE A SUSPEN
      DED CEILING IN YOUR": PRINT
      "PLANS ADD AN  R-VALUE OF 1.
      0 TO THE": PRINT "TOTAL R-VA
      LUES FOR THE EFFECT OF THE A
      IR": PRINT "SPACE."
1828  PRINT "REMEMBER TO ADD THE
      TILE'S R-VALUE ": PRINT "ALO
      NG WITH THE AIR SPACE AND AN
      Y OTHER": PRINT "ADDITIONS."

1830  RETURN
1900  REM  SUSPENDED CEILING
1901  LET Q = .166 * A * B * 50
1999  RETURN
2000  REM FLOOR ROUTINE
2001  LET A = 0: LET B = 0: LET C
      = 0: LET R = 0: LET TR = 0
2005  HOME : VTAB (4): PRINT "THI
      S PART OF THE PROGRAM WILL A
      SK YOU": PRINT "SEVERAL QUES
      TIONS ABOUT THE FLOOR IN"
2010  PRINT "THE BUILDING(S) IN Q
      UESTION.": PRINT : PRINT "YO
      U SHOULD RESPOND WITH (Y) OR
       (N) TO"
2015  PRINT "EACH QUESTION.  IN T
      HE EVENT YOU HAVE": PRINT "A
      DDED ADDITIONAL INSULATING M
      ATERIALS"
2020  PRINT "YOU WILL BE REQUIRED
       TO ENTER THE ": PRINT "CORR
      ECT VALUE FROM THE TABLE WHI
      CH WILL"
2025  PRINT "APPEAR ON THE SCREEN
      "
2030  VTAB (20): INVERSE : PRINT
      "HIT ANY KEY TO CONTINUE..."
      : NORMAL : GET A$
2035  HOME
2099  REM  SLAB-ON-GRADE
2100  VTAB (20): PRINT "DO YOU HA
      VE A SLAB-ON-GRADE FLOOR ? (
      Y)";: PRINT " OR (N)": GET A
      $
2105  IF A$ = "Y" GOTO 2150
2110  IF A$ = "N" GOTO 2200
2150  HOME : PRINT "YOU HAVE NO A
      PPRECIABLE HEAT LOSS ": PRINT
      "THROUGH THE FLOOR.  FOR THE
       PURPOSE OF "
```

```
2155  PRINT "THIS ANALYSIS YOU MA
      Y CONSIDER THE LOSS": PRINT
      "EQUAL TO 0 BTU/HR."
2157  PRINT : PRINT : PRINT : PRINT
      : PRINT "HIT ANY KEY TO CONT
      INUE"
2158  GET A$
2160  RETURN
2200  REM  FLOOR NOT ON GRADE
2201  HOME : VTAB (7)
2205  PRINT "THE ANALYSIS FOR THE
       FLOOR IS BASED UPON";: PRINT
      "THE FOLLOWING BASIC MATERIA
      LS.  IF YOUR"
2210  PRINT "CONSTRUCTION HAS ADD
      ITIONAL MATERIALS ": PRINT "
      YOU WILL NEED TO ADD THEM FR
      OM THE TABLE";
2215  PRINT "OF VALUES WHICH WILL
       BE PRESENTED"
2220  PRINT : PRINT : PRINT "THE
      TYPICAL FLOOR IS A 3 IN. CON
      CRETE": PRINT "SLAB OVER MET
      AL LATH WITH TILE."
2221  PRINT "THE FORMULA USED IS
      AS FOLLOWS:"
2222  PRINT : PRINT  TAB( 8)"Q=UA
      ΔT"
2225  PRINT : PRINT : PRINT "WHAT
       ARE THE DIMENSIONS OF YOUR
      BUILDING ?": INPUT A,B
2230  REM  U-VALUE FOR BASE FLOOR
       IS 0.2 BTU/HR/SQ.FT.
2233  LET C = A * B * .2 * 10: LET
      C =  INT (C)
2235  HOME : VTAB (5): PRINT "THE
       HEAT LOSS FROM YOUR FLOOR I
      S ";C;" BTU/HR."
2240  PRINT "HAVE YOU ADDED ADDIT
      IONAL MATERIALS TO ": PRINT
      "YOUR FLOORS OR WISH TO SEE
      Q-VALUES FROM";
2245  PRINT "PROPOSED ADDITIONS ?"
      : GET A$
2250  IF A$ = "N" GOTO 2999
2300  REM  TABLE OF VALUES AND AD
      DITIONS
2301  HOME
2304  INVERSE
2305  PRINT "
                              ": NORMAL
```

```
2310  VTAB (10): PRINT : PRINT  TAB(
      7)"CARPET & FIBROUS PAD--2.0
      8"
2315  PRINT  TAB( 7)"CARPET & RUB
      BER PAD--1.23"
2320  PRINT  TAB( 7) "HARDWOOD FIN
      ISH--.68"
2327  PRINT  TAB( 7)"BATT/BLANKET
      --3.14 R/IN"
2330  PRINT : PRINT : INVERSE : PRINT
      "WHAT IS THE TOTAL ADDITIONA
      L R-VALUE ?": INPUT TR
2331  NORMAL
2334  LET R = (1 / (5.02 + TR)): LET
      R = R * A * B * 10: LET R =
       INT (R)
2335  PRINT : PRINT : PRINT "THE
      HEAT LOSS WITH THS AMOUNT OF
       INSUL-": PRINT "ATING MATER
      IAL IS ";R'"BTU/HR"
2340  PRINT "THIS IS A SAVINGS OF
       ";C - R;" BTU/HR"
2500  PRINT : PRINT : PRINT : INVERSE
      : PRINT "HIT ANY KEY TO CONT
      INUE": NORMAL : GET A$
2999  RETURN
3000  REM  INFILTRATION ROUTINE
3001  LET WA = 0: LET 12 = 0: LET
      W = 0: LET WI = 0: LET NW =
      0: LET F = 0: LET IN = 0: LET
      IL = 0
3005  HOME : VTAB (4): PRINT "THI
      S PART OF THE PROGRAM WILL A
      SK YOU": PRINT "SEVERAL QUES
      TIONS ABOUT INFILTRATION IN"

3010  PRINT "THE BUILDING(S) IN Q
      UESTION.": PRINT : PRINT "YO
      U SHOULD RESPOND WITH (Y) OR
       (N) TO"
3015  PRINT "QUESTIONS OR BY ENTE
      RING NUMBERS AS": PRINT "REQ
      UESTED."
3030  VTAB (20): INVERSE : PRINT
      "HIT ANY KEY TO CONTINUE..."
      : NORMAL : GET A$
3035  HOME
3040  PRINT "IN ORDER TO FIGURE I
      NFILTRATION IT IS ": PRINT "
      NECESSARY TO HAVE VALUES FOR
       WALL": PRINT "SQUARE FOOTAG
      E AND WINDOW PERIMETERS."
```

```
3045  PRINT "IT WILL BE NECESSARY
      TO MAKE SOME ": PRINT "ASSU
     MPTIONS ABOUT THE VENTILATIN
     G AIR"
3050  PRINT "AND BUILDING PRESSUR
     IZATION."
3060  PRINT "DO YOU HAVE BRICK WA
     LLS ?": GET W$: IF W$ = "Y" THEN
     W = 8: REM  WALL INFILTRATIO
     N FROM ASHRAE 22.11
3065  IF W$ = "N" THEN PRINT "DO
      YOU HAVE WOOD FRAME WALLS ?
     ": GET W$: IF W$ = "Y" THEN
     W = 3: REM  FROM ASHRAE 22.1
     1
3074  REM WALL AREA
3075  INPUT "WHAT IS THE AREA OF
     THE WALL (SQ.FT.)";WA
3079  REM  CALCULATE WALL INFILTR
     ATION
3080 WI = W * WA
3100  REM  GET WINDOW INFORMATION

3101  HOME
3104  LET I2 = IL: REM  KEEP ORIG
     . VALUE
3105  PRINT "FROM THE FOLLOWING S
     ELECT THE ONE WHICH BEST DES
     CRIBES YOUR WINDOWS :"
3110  VTAB (7): PRINT  TAB( 3)"1.
      LOOSE FITTING WITH OR WITHO
     UT": PRINT "     WEATHERSTRI
     PPING"
3111  PRINT  TAB( 3)"2. AVERAGE F
     IT WITH WEATHERSTRIPPIG"
3112  PRINT  TAB( 3)"3. AVERAGE F
     IT WITHOUT WEATHERSTRIP"
3114  REM  GET WINDOW LEAKAGES
3115  FLASH : PRINT "ENTER THE NU
     MBER": NORMAL : GET W
3120  IF W = 1 THEN W = 77: IF W =
     2 THEN W = 14: IF W = 3 THEN
     W = 27
3125  HOME
3130  PRINT "WHAT IS THE TOTAL PE
     RIMETER IN FEET OF": PRINT "
     ALL WINDOWS ?": INPUT NW
3135 W = NW * W: REM  GET TOTAL W
     INDOW LOSS
3140  HOME
3145  PRINT "SELECT HOW YOUR WIND
     OWS ARE SET FROM ": PRINT "T
     HE FOLLOWING MENU:  "
```

```
3150  VTAB (7): PRINT  TAB( 5)"1.
     MASONERY WALL, NOT CAULKED"

3155  PRINT  TAB( 5)"2. MASONERY
     WALL, CAULKED"
3160  PRINT  TAB( 5)"3. FRAME WAL
     L, CAULKED OR NOT"
3161  REM  DATA FROM ASHRAE  22.9

3170  PRINT : PRINT : FLASH : PRINT
     "ENTER NUMBER": GET F
3175  IF F = 1 THEN F = 17: IF F =
     2 THEN F = 3: IF F = 3 THEN
     F = 13
3180 F = NW * F: REM  GET FRAME L
     OSS
3200  REM  CALCULATE BTU/HR LOSS
3201  HOME
3205  VTAB (5): PRINT "THE INFILT
     RATION CALCULATIONS ARE BASE
     D": PRINT "ON THE FOLLOWING
     FORMULA :"
3210  INVERSE : PRINT  TAB( 15)"Q
     =MCΔT                    ": NORMAL

3215  PRINT : PRINT : PRINT : PRINT
     "WHERE Q= HEAT LOSS IN BTU/H
     R; M=MASS OF": PRINT "AIR;C=
     SPECIFIC HEAT; AND ΔT=CHANGE
      IN": PRINT "TEMPERATURE"
3220  FLASH : PRINT "HIT ANY KEY
     TO CONTINUE": GET A$
3221  NORMAL
3225  HOME : VTAB (15)
3229  REM  SUM ALL CFH FIGURES
3230  LET IN = WI + W + F
3235  LET IL = .018 * IN * 50: REM
      IINFILTRATION LOSS
3236 IL =  INT  (IL)
3240  PRINT "THE TOTAL HEAT LOSS
     DUE TO INFILTRATION": PRINT
     "IS ";IL;" BTU/HR."
3241  IF I2 = < IL THEN  GOTO 32
     45
3242  PRINT "YOUR SAVINGS DUE TO
     THE UPGRADE ARE ";I2 - IL;"
     BTU/ HR."
3245  VTAB (20): PRINT "HIT ANY K
     EY TO CONTINUE": GET A$
3250  HOME
3300  REM . CHECK TO SEE IF THERE
     IS INSULATION ADDED
```

```
3301  VTAB (10): PRINT "HAVE THERE
      BEEN ADDITIONAL  INSULATING
      ": PRINT "MATERIALS ADDED OR
      DO YOU WISH TO "
3305  PRINT "CONSIDER THEIR ADDIT
      ION ?": GET A$
3310  IF A$ = "Y" THEN GOTO 3100

3999  RETURN
4000  REM  WALL ROUTINE
4001  LET WA = 0: LET W = 0: LET
      WL = 0: LET WR = 0: LET TW =
      0
4005  HOME : VTAB (4): PRINT "THI
      S PART OF THE PROGRAM WILL A
      SK YOU": PRINT "SEVERAL QUES
      TIONS ABOUT THE WALLS IN THE"
4010  PRINT "BUILDING(S) IN QUEST
      ION.": PRINT "YOU SHOULD RES
      POND WITH (Y) OR (N) TO"
4015  PRINT "EACH QUESTION.  IN T
      HE EVENT YOU HAVE": PRINT "A
      DDED ADDITIONAL INSULATING M
      ATERIALS"
4020  PRINT "YOU WILL BE REQUIRED
       TO ENTER THE": PRINT "CORRE
      CT VALUE FROM THE TABLE WHIC
      H WILL"
4025  PRINT "APPEAR ON THE SCREEN
      ."
4030  VTAB (20): INVERSE : PRINT
      "HIT ANY KEY TO CONTINUE..."
      : NORMAL : GET A$
4035  HOME
4040  PRINT "THE ANALYSIS IS BASE
      D UPON THE FOLLOWING";: PRINT
      "ASSUMPTIONS AS FAR AS THE B
      ASIC "
4045  PRINT "CONSTRUCTION IS CONC
      ERNED.  IF YOU HAVE": PRINT
      "ADDED OR PLAN TO ADD MATERI
      ALS ABOVE THE";
4050  PRINT "BASIC WALL YOU MUST
      ENTER THE R-VALUE": PRINT "F
      OR THESE ADDITIONS WHEN ASKE
      D TO DO SO."
4055  PRINT : PRINT "THE BASIC WA
      LL IS COMPOSED OF A 4 IN.": PRINT
      "COMMON BRICK; A NONREFLECTI
      VE AIR SPACE;";
4060  PRINT "AND A 4 IN. CINDER A
      GGREGATE BLOCK"
```

```
4065  PRINT : PRINT : PRINT "THE
      FORMULA USED FOR THIS CALCUL
      ATION": PRINT "IS": INVERSE
      : PRINT "Q=UAΔT": NORMAL " PRINT
      : PRINT
4070  INVERSE : PRINT "HIT ANY KE
      Y TO CONTINUE": NORMAL " GET
      A$
4100  HOME
4105  PRINT "PLEASE ENTER THE TOT
      AL SQUARE FOOTAGE": PRINT "O
      F YOUR WALLS MINUS THE WINDO
      W AREA": INPUT W
4108  LET WL = .289 * W * 50: LET
      WL = INT (WL)
4110  VTAB (11): PRINT "IF YOU HA
      VE THE BASIC WALL THE HEAT L
      OSS";: PRINT "IS EQUAL TO ";
      WL;" BTU/HR"
4115  INVERSE : PRINT "HIT ANY KE
      Y TO CONTINUE": NORMAL : GET
      A$
4120  HOME
4125  PRINT "HAVE YOU ADDED OR WO
      ULD YOU LIKE TO KNOW";: PRINT
      "THE EFFECT OF ADDING ADDITI
      ONAL INSUL-"
4130  PRINT "ATING MATERIALS? (Y)
       OR (N)": GET A$: IF A$ = "N
      " THEN  RETURN
4135  HOME
4140  VTAB (10)
4145  PRINT  TAB( 3)"REFLECTIVE A
      IR SPACE--1.75": PRINT
4150  PRINT  TAB( 3)"FILLED BLOCK
       CORES--1.5": PRINT
4155  PRINT  TAB( 3)".5 IN GYPSUM
       WALL BOARD--.45": PRINT
4160  PRINT  TAB( 3)"POLYURETHANE
       FOAM--5.88": PRINT
4165  PRINT  TAB( 3)"UREAFORMALDE
      HYDE FOAM--4.0": PRINT
4170  PRINT  TAB( 3):CELLULOSIC F
      IBER SPRAY--3.7": PRINT
4175  PRINT  TAB( 3)"PERLITE OR V
      ERMICULITE SPRAY--1.67": PRINT

4180  PRINT "ENTER THE TOTAL ADDI
      TIONAL R-VALUE FROM": PRINT
      "THE TABLE OR FROM VENDORS O
      F UNLISTED"
4185  PRINT "MATERIALS TO GET A T
      OTAL WALL HEAT LOSS": INPUT
      WR
```

```
4186  LET TW = (1 / (3.48 + WR)) *
      W * 50: LET TW =  INT (TW)
4190  PRINT "THE ADDITIONAL INSUL
      ATION YIELDS A HEAT": PRINT
      "LOSS OF ";TW;" BTU/HR."
4200  PRINT "THIS IS A DIFFERENCE
       OF ";WL - TW;" BTU/HR."
4201  LET WA = WL - TW
4999  RETURN
5000  REM  WINDOW ROUTINE
5005  HOME : VTAB (4): PRINT "THI
      S PART OF THE PROGRAM WILL A
      SK YOU": PRINT "SEVERAL QUES
      TIONS ABOUT THE WINDOWS IN"
5010  PRINT "BUILDING(S) IN QUEST
      ION.": PRINT "YOU SHOULD RES
      POND WITH (Y) OR(N) TO"
5015  PRINT "EACH QUESTION.  THER
      E WILL BE A CHANCE": PRINT "
      TO FIND OUT THE EFFECT OF UP
      GRADING "
5020  PRINT "WINDOWS IN YOU BUIL
      DING."
5025  PRINT "APPEAR ON THE SCREEN
      ."
5030  VTAB (20): INVERSE : PRINT
      "HIT ANY KEY TO CONTINUE..."
      : NORMAL : GET A$
5035  HOME
5040  PRINT "IN KEEPING WITH OUR
      CONVENTION OF USING": PRINT
      "WINTER DESIGN CONDITIONS AL
      L DATA"
5045  PRINT "WILL BE FOR WINTER D
      ESIGN CONDITIONS."
5050  PRINT "IT WILL BE NECESSARY
       FOR YOU TO SUPPLY": PRINT "
      CERTAIN INFORMATION ABOUT TH
      E AREA OF"
5055  PRINT "GLASS FACING IN VARI
      OUS DIRECTIONS": PRINT "TYPE
       IN THE AREAS AS REQUESTED T
      HEN"
5060  PRINT "HIT THE (RETURN) KEY
      "
5063  PRINT : PRINT
5064  REM  GET WINDOW AREAS AND D
      IRECTIONS
5065  PRINT "WHAT IS THE WINDOW A
      REA FACING NORTH ?": INPUT N
      : PRINT "WHAT IS THE AREA FA
      CING NORTHEAST?": INPUT NE
```

```
5070  PRINT "WHAT IS THE AREA FAC
      ING EAST ?": INPUT E: PRINT
      "WHAT IS THE AREA FACING SOU
      THEAST?": INPUT SE
5075  PRINT "WHAT IS THE AREA FAC
      ING SOUTH?": INPUT S: PRINT
      "WHAT IS AREA FACING SOUTHWE
      ST?": INPUT SW
5080  PRINT "WHAT IS THE AREA FAC
      ING WEST?": INPUT W: PRINT "
      WHAT IS THE AREA FACING NORT
      HWEST?": INPUT NW
5085  REM  TOTAL ALL WINDOW AREAS

5090  LET WT = N + NE + E + SE +
      S + SW + W + NW
5100  REM  GET WINDOW U-VALUES
5101  HOME
5105  PRINT "YOU WILL NEED TO SUP
      PLY ONE OTHER BIT": PRINT "O
      F DATA CONCERNING YOUR WINDO
      WS."
5110  PRINT "ARE YOUR WINDOWS OF
      SINGLE GLASS ": PRINT "CONST
      RUCTION ?": GET W$
5111  IF W$ = "Y" GOTO 5200
5115  PRINT "DO YOU HAVE STORM WI
      NDOWS ?": GET W$: IF W$ = "Y
      " GOTO 5250
5120  PRINT "DO YOU HAVE DOUBLE P
      ANED WINDOWS?": GET W$: IF W
      $ = "N" THEN  PRINT "ARE YOU
       SURE ABOUT THESE ANSWERS ?"
      : GOTO 5110
5124  HOME : VTAB (5)
5125  PRINT "THE HEAT COEFFICIENT
      FORMULA WHICH WILL": PRINT
      "BE USED WILL BE": PRINT : PRINT
      : PRINT : PRINT  TAB( 12)"Q=
      UAΔT":
5130  PRINT : PRINT : PRINT "WINT
      ER DESIGN CONDITIONS WILL BE
      USED."
5135  PRINT : PRINT : PRINT : INVERSE
      : PRINT "HIT ANY KEY TO CONT
      INUE": NORMAL : GET A$
5140  HOME : VTAB (15)
5142  LET L2 = WT * .62 * 50:L2 =
      INT (L2)
5145  PRINT "HEAT LOSS FROM YOUR
      DOUBLE GLAZED": PRINT "WINDO
      WS IS EQUAL TO ";L2
5146  PRINT "BTU/HR."
```

```
5150  PRINT : PRINT : PRINT : PRINT
      TAB( 4)"HIT ANY KEY TO CONT
     INUE": GET A$: GOTO 5285
5199  HOME : VTAB (5)
5200  PRINT "THE HEAT COEFFICIENT
     FORMULA WHICH WILL": PRINT
     "BE USED WILL BE": PRINT : PRINT
     : PRINT : PRINT  TAB( 12)"Q=
     UAΔT"
5205  PRINT : PRINT : PRINT "WINT
     ER DESIGN CONDITIONS WILL BE
     USED."
5210  PRINT : PRINT : PRINT : INVERSE
     : PRINT "HIT ANY KEY TO CONT
     INUE": NORMAL : GET A$
5215  HOME : VTAB (15)
5217  LET WL = WT * 1.1 * 50:WL =
      INT (WL)
5220  PRINT "HEAT LOSS FROM YOUR
     SINGLE GLAZED": PRINT "WINDO
     WS IS EQUAL TO ";WL
5221  PRINT "BTU/HR."
5225  PRINT : PRINT : PRINT : PRINT
     : PRINT  TAB( 5)"HIT ANY KEY
      TO CONTINUE": GET A$: GOTO
     5285
5249  HOME : VTAB (5)
5250  PRINT "THE HEAT COEFFICIENT
      FORMULA WHICH WILL": PRINT
     "BE USED WILL BE": PRINT : PRINT
     : PRINT : PRINT  TAB( 12)"Q=
     UAΔT"
5255  PRINT : PRINT : PRINT "WINT
     ER DESIGN CONDITIONS WILL BE
      USED."
5260  PRINT : PRINT : PRINT : INVERSE
     : PRINT "HIT ANY KEY TO CONT
     INUE": NORMAL : GET A$
5265  HOME : VTAB (15)
5267 L3 = WT * .50 * 50:L3 =  INT
     (L3)
5270  PRINT "HEAT LOSS FROM YOUR
     STORM SASHED ": PRINT "WINDO
     WS IS EQUAL TO ";L3
5271  PRINT "BTU/HR."
5280  PRINT : PRINT : PRINT : PRINT
     : PRINT  TAB( 5):HIT ANY KEY
      TO CONTINUE": GET A$
5285  HOME : VTAB (10): PRINT "WO
     ULD YOU LIKE TO SEE THE LOSS
      SHOULD"
5286  PRINT "YOU UPGRADE YOUR WIN
     DOWS ?": GET A$: IF A$ = "Y"
      THEN  HOME : GOTO 5115
```

```
5287  PRINT "DO YOU WISH TO SEE S
      AVINGS ?": GET A$
5290  IF A$ = "N" GOTO 5302
5300  PRINT : PRINT : IF L2 > 0 THEN
       PRINT "YOUR SAVINGS WITH DO
      UBLE GLAZING+ ";WL - L2;" BT
      U/HR"
5301  IF L3 > 0 THEN  PRINT "WITH
       STORM WINDOWS THE SAVINGS A
      RE ";WL - L3;" BTU/HR.": PRINT
      : PRINT
5302  PRINT "HIT ANY KEY TO CONTI
      NUE": GET A$
5303  REM  SOLAR HEAT GAIN FROM W
      INDOWS
5304  HOME : VTAB (10)
5305  REM  DATA FROM ASHRAE 1981
      CHAP.26 TAB.11A
5310  PRINT "DECEMBER IS THE MONT
      H CHOSEN FOR THE ": PRINT "C
      ALCULATIONS SINCE THIS IS TH
      E LEAST "
5315  PRINT "SOLAR HEAT GAIN MONT
      H."
5320  PRINT "DATA ASSUME SUNNY DA
      YS.  IF THERE IS ": PRINT "C
      LOUD COVER ASSUME NO HEAT GA
      IN."
5325  PRINT "THE DESIGN LATITUDE
      IS 36 DEG NORTH."
5330  LET N = N * 20: LET NE = NE
       * 20: LET NW = NW * 20: LET
      E = E * 151: LET W = W * 151
      : LET SE = SE * 241: LET SW =
      SW * 241: LET S = S * 254
5335  LET ST = N + NE + NW + E +
      W + SE + SW + S
5340  PRINT "THE TOTAL SOLAR HEAT
       GAIN FOR THE MONTH": PRINT
      "OF DECEMBER IS EQUAL TO ";S
      T;" BTU/HR."
5999  RETURN
6000  REM  TALLY SUBROUTINE
6001  HOME : PRINT : PRINT : PRINT
      : PRINT : PRINT : PRINT : PRINT
      : PRINT :
6005  PRINT "THIS IS THE TALLY SE
      CTION FOR THE ": PRINT "BUIL
      DING ANALYSIS PROGRAM."
6009  HOME : PRINT : PRINT : PRINT
      : PRINT : PRINT
```

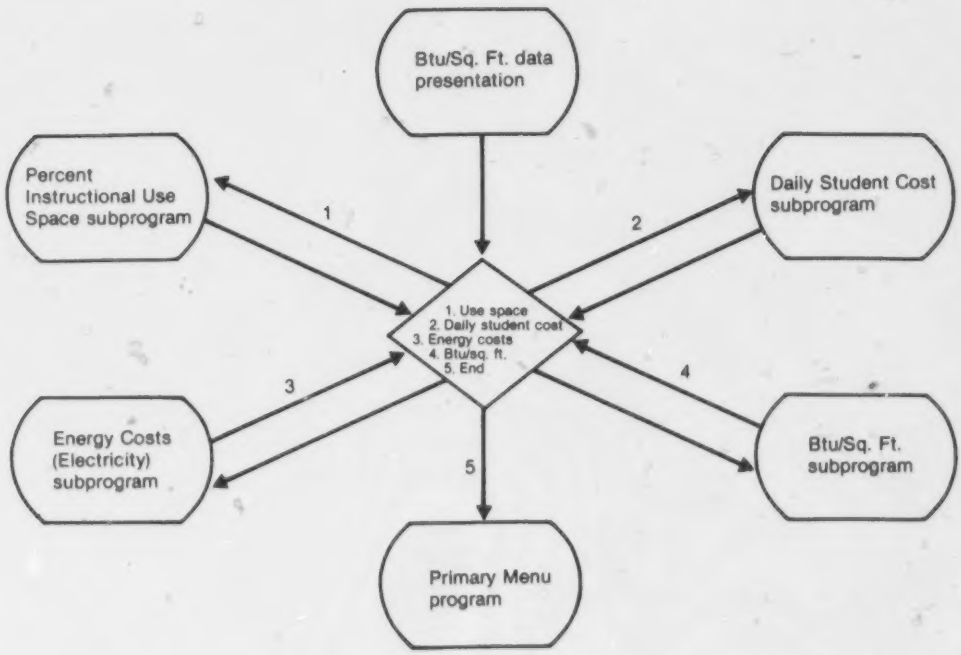
```
6010  PRINT "YOU MUST INDICATE YO
      UR RESPONSES BY ": PRINT "TY
      PING A (1) FOR YES OR  A (2)
       FOR NO."
6011  FLASH : SPEED= 100: PRINT "
      U S E  N U M B E R S  (1) OR
       (2) ": NORMAL : SPEED= 255:
       PRINT : PRINT : PRINT :
6015  PRINT : PRINT : PRINT "DID
      YOU CONSIDER ROOF IMPROVEMEN
      TS ?": GET R: IF R = 1 THEN
      R = Q2 + (Q - Q1)
6017  IF R = 2 THEN R = 0
6020  PRINT : PRINT "DID YOU CONS
      IDER FLOOR IMPROVEMENTS ?": GET
      F: IF F = 1 THEN F = C - R: IF
      F = 2 THEN F = 0
6030  PRINT : PRINT "DID YOU CONS
      IDER INFILTRATION IMPROVE-":
       PRINT "MENTS ?": GET I: IF
      I = 1 THEN I = (I2 - IL): IF
      I = 2 THEN I = 0
6040  PRINT : PRINT "DID YOU CONS
      IDER WALL IMPROVEMENTS ?": GET
      WA: IF WA = 1 THEN WA = WA: IF
      WA = 2 THEN WA = 0
6049  PRINT
6050  PRINT "DID YOU CONSIDER WIN
      DOW IMPROVEMENTS ?": GET WI:
       IF WI = 1 THEN WI = WL - (L
      2 + L3): IF WI = 2 THEN WI =
      0
6099  GOSUB 7000
6100  LET TT = WI + WA + I + F +
      R
6106  PRINT : PRINT : PRINT "HIT
      ANY KEY TO CONTINUE": GET AN
      $
6109  HOME
6110  PRINT "THE BTU HEAT LOSS IS
       CALCULATED USING ": PRINT "
      A MODIFICATION OF THE DEGREE
      -DAY METHOD": PRINT "THE FOR
      MULA IS SHOWN BELOW:": PRINT
      : PRINT : PRINT
6111  REM  DEGREE-DAY FORMULA MOD
      IFIED FROM ASHRAE 1981 FUNDA
      MENTALS VOLUME
6114  PRINT  TAB( 4):    (HL) X (
      D) X (24):
6115  PRINT  TAB( 5)"E=----------
      --------- (CD)"
```

```
6116  PRINT  TAB( 5):     (ΔT) X
     (K) X (V)"
6117  PRINT : PRINT : PRINT
6120  PRINT "E=ENERGY USE FOR THE
     PERIOD (BTU)"
6121  PRINT "HL-DESIGN HEAT LOSS
     (BTU/HR)"
6122  PRINT "D-NUMBER OF DEGREE-D
     AYS"
6123  PRINT "24=DATA CONVERSION T
     O HOURS"
6124  PRINT "ΔT=DESIGN TEMPERATUR
     E DIFFERENCE"
6125  PRINT "K=EFFICIENCY COEFFIC
     IENT FACTOR"
6126  PRINT "V-HEATING VALUE OF F
     UEL"
6127  PRINT "CD-CORRELATION FACTO
     R FOR DEGREE-DAYS"
6128  PRINT : PRINT : PRINT "HIT
     ANY KEY TO CONTINUE": GET A$
     : HOME
6129  PRINT "YOUR TOTAL SAVINGS C
     ONSIDERING DEGREE-": PRINT "
     DAY MODIFICATION ARE ";: INVERSE
     : PRINT TT * 3265 * .7;: NORMAL
     : PRINT " BTU."
6131  PRINT "HIT ANY KEY TO CONTI
     NUE": GET A$
6199  HOME
6200  PRINT : PRINT : PRINT: PRINT
     "IF YOU HAVE OTHER ANALYSES
     YOU WISH TO ": PRINT "DO THE
     N PRESS THE 'Y' KEY.": GET A
     N$: IF AN$ = "Y" THEN  GOTO
     39
6205  REM  RETURN TO PRIMARY MENU

6210  PRINT D$;"RUN PRIMARY MENU"

6999  RETURN
7000  REM  DEGREE-DAY CORRECTION
     TO BTU LOSS
7004  HOME
7005  PRINT "SELECT HOW YOUR BUIL
     DING IS HEATED FROM THE LIST
      BELOW:"
7010  PRINT  TAB( 7)"1. OIL"
7015  PRINT  TAB( 7)"2. NATURAL G
     AS"
7020  PRINT  TAB( 7)"3. ELECTRICI
     TY"
7025  PRINT  TAB( 7)"4. COAL"
```

```
7030  PRINT  TAB( 7)"5. PROPANE"
7035  PRINT : PRINT : PRINT "SELE
     CT BY THE NUMBER PLEASE"
7040  GET A: IF A < 1 OR A > 5 THEN
      GOTO 7040
7045  IF A = 1 OR A = 2 THEN HV =
     .55
7049  REM  HV=AVG. EFFICIENCY FAC
     TOR
7050  IF A = 3 THEN HV = 1: IF A =
     4 THEN HV = .45: IF A = 5 THEN
     HV = .6
7100  RETURN
63000  REM  COPYRIGHT- STEPHEN CA
     NIPE 1982 MATTHEWS  NC 28105
```

Figure 66

Btu/Sq. Ft.



Represented on this flow chart are the possible choices from the Btu/Sq. Ft. subprogram.

Figure 67

Percent Instructional Use Space Subprogram

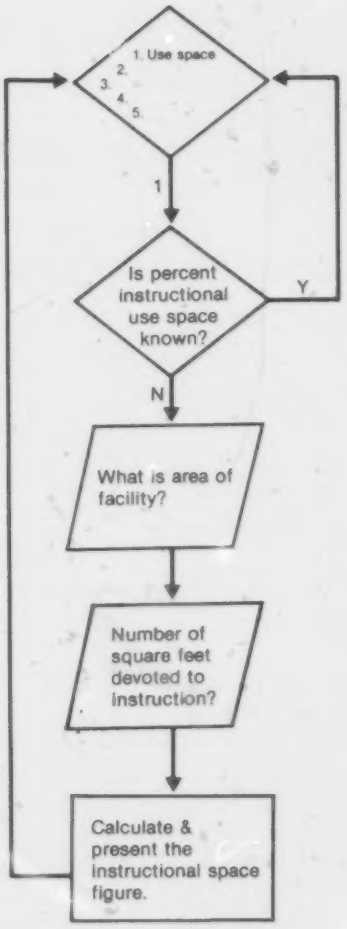


Figure 68

Total Daily Student Costs Subprogram

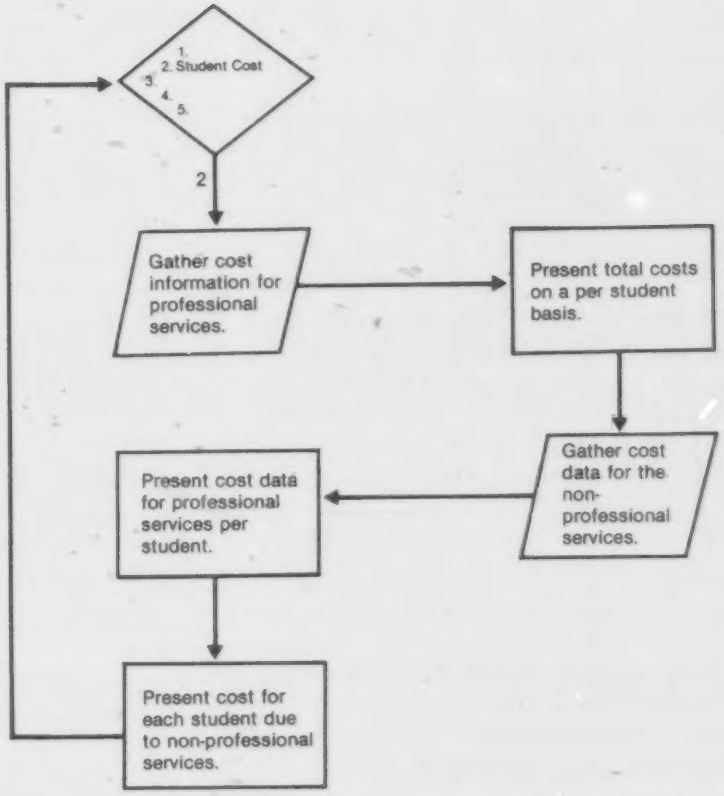

1.
2. Student Cost
3.
4.
5.
2
Gather cost information for professional services.
Present total costs on a per student basis.
Gather cost data for the non-professional services.
Present cost data for professional services per student.
Present cost for each student due to non-professional services.

Figure 69

Energy Cost (Electric) Subprogram

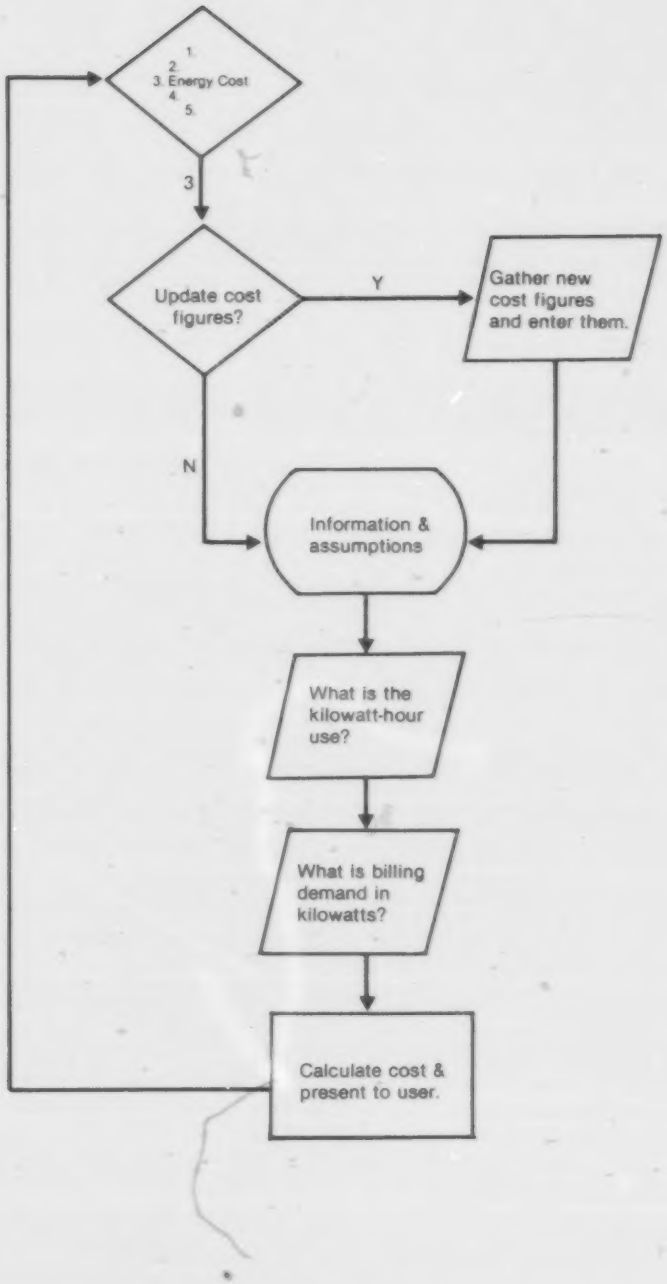


Figure 70

Btu/Sq. Ft. Subprogram

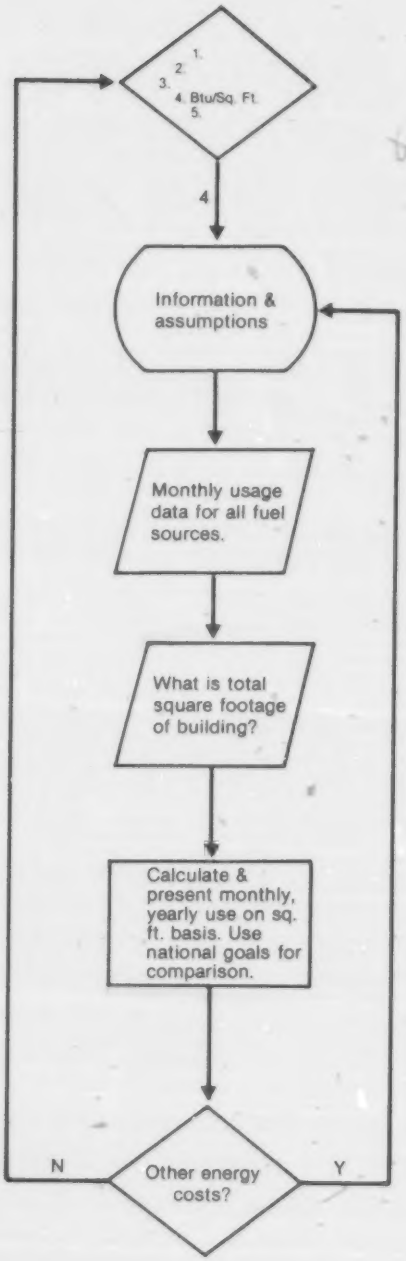
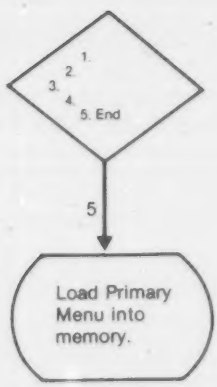


Figure 71

End Subprogram



Btu per Square Foot Program Listing

```
0    SPEED= 255
1    TEXT : HOME
3    INVERSE : PRINT : PRINT  TAB(
       10)"BTU PER SQUARE FOOT
             : NORMAL : PRINT : PRINT

10   PRINT "THIS PROGRAM IS DESIGN
      ED FOR THE SCHOOL": PRINT "A
      DMINSTRATOR WHO WANTS TO BEC
      OME MORE"
11   PRINT "FAMILIAR WITH THE USE
      OF THE COMPUTER IN";: PRINT
      "MANAGING THE FACILITIES AND
      IN UNDER-"
12   PRINT "STANDING THE BUDGET CO
      STS ASSOCIATED": PRINT "WITH
       ENERGY USE."
13   PRINT : PRINT "USE OF THIS SE
      RIES OF PROGRAMS": PRINT "WI
      LL NOT MAKE YOU AN EXPERT. B
      UT WILL"
14   PRINT "ENABLE YOU TO MAKE COM
      PUTER-ASSISTED": PRINT "DECI
      SIONS.  THERE WILL BE A MENU
      "
15   PRINT "PRESENTED FOR YOU TO S
      ELECT THE TOPIC": PRINT "THA
      T YOU WISH TO EXPLORE.  ALL
      YOU"
16   PRINT "NEED TO DO IS TO PRESS
       THE PROPER NUMBER ";: PRINT
      "FOR THAT PART OF THE PROGRA
      M TO EXECUTE"
18   FLASH : PRINT "HIT ANY KEY TO
       SEE MENU": NORMAL
20   GET C$
21   ONERR  GOTO 49
24   HOME : PRINT : CLEAR
25   PRINT "           M  E  N  U
      "
26   PRINT "----------------------
      ----------------": PRINT : PRINT

28   PRINT "1. PERCENT INSTRUCTION
      AL USE SPACE"
29   PRINT "2. TOTAL DAILY STUDENT
       COSTS"
30   PRINT "3. ENERGY COSTS"
31   PRINT "4. BTU'S PER SQUARE FO
      OT"
32   PRINT "5. END"
```

```
39   PRINT : PRINT
49   FLASH : PRINT "PRESS THE NUMB
      ER OF THE ROUTINE NEEDED ": NORMAL
50   GET I: HOME : IF I = 1 THEN  GOSUB
      1000: GOTO 200
51   IF I = 2 THEN  GOSUB 2000: GOTO
      200
52   IF I = 3 THEN  GOSUB 3000: GOTO
      200
53   IF I = 4 THEN  GOSUB 4000: GOTO
      200
200  PRINT
250  VTAB (7)
251  PRINT "              THANK  Y
     OU  "
499  LET D$ =  CHR$ (4): REM  CNT
     RL-D
500  VTAB (18): PRINT "IF YOU WIS
     H TO RETURN TO THE MAIN MENU
     ": PRINT "TYPE 'Y' OTHERWISE
      ANY KEY TO END."
501  GET A$: IF A$ = "Y" THEN  PRINT
     D$;" RUN PRIMARY MENU"
999  END
1000 PRINT "THIS ROUTINE FIGURES
     OUT THE PERCENT OF SPACE DE
    VOTED TO INSTRUCTIONAL USES
    IF ";: PRINT "YOU ALREADY K
    NOW THIS FIGURE TYPE 'Y' TOR
    ETURN TO THE MENU"
1001 PRINT "OTHERWISE HIT RETURN
     TO CONTINUE"
1005 GET Y$: IF Y$ = "Y" THEN  GOTO
    24
1008 HOME
1009 PRINT "YOU CAN USE THIS PRO
    GRAM FOR THE ENTIRE SCHOOL
    OR FOR PARTICULAR CLASSROOMS
    .": PRINT : PRINT
1010 PRINT "WHAT IS THE AREA OF
    THE FACILITY (IN    SQUARE F
    EET) ?": INPUT "ENTER THE NU
    MBER, THEN TYPE RETURN";SF
1014 PRINT
1015 INPUT "HOW MANY SQUARE FEET
     ARE DEVOTED TO IN- STRUCTIO
    NAL PURPOSES ? ENTER THE NUM
    BER THEN HIT RETURN";IP
1016 PRINT
1019 LET IU = (IP / SF) * 100
1020 PRINT "THE PERCENT OF INSTR
    UCTIONAL USE SPACE  IS ";IU
1099 PRINT : PRINT : PRINT
```

```
1100  PRINT "HIT RETURN TO CONTIN
      UE": GET R$
1999  GOTO 24: RETURN
2000  PRINT "THIS ROUTINE FIGURES
       THE TOTAL DAILY": PRINT "ST
      UDENT COST.  IF YOU ALREADY
      KNOW THIS": PRINT "TYPE Y TO
       RETURN TO MENU"
2001  PRINT "OTHERWISE HIT RETURN
       TO CONTINUE"
2005  GET Y$: IF Y$ = "Y" THEN  GOTO
      24
2009  HOME
2010  PRINT "IN ORDER TO FIGURE C
      OSTS ON A STUDENT   BASIS IT
       IS NECESSARY FOR YOU TO HAV
      E   THE FOLLOWING DATA:  "
2011  PRINT : PRINT  TAB( 7);"1.
      CENTRAL ADMINISTRATIVE COSTS"
      : PRINT  TAB( 7);"2. TOTAL N
      UMBER OF TEACHERS": PRINT  TAB(
      7);"3. SCHOOL SERVICE COST"
2012  PRINT  TAB( 7);"4. AVERAGE
      TEACHER COST SALARY": PRINT
       TAB( 7);"5. TRANSPORTATION
      COSTS"
2013  PRINT  TAB( 7)"6. TOTAL NUM
      BER OF STUDENTS": PRINT  TAB(
      7)"7. NUMBER OF TEACHERS IN
      SCHOOL": PRINT  TAB( 7)"8. M
      AINTENANCE AND OPERATING COS
      TS"
2014  PRINT  TAB( 7);"9. % INSTRU
      CTIONAL USE SPACE": PRINT  TAB(
      9);"(SEE MENU FOR HELP, IF NE
      EDED)"
2020  INPUT "WHAT IS THE CENTRAL
      ADMINISTRATIVE COST  (IN DOLL
      ARS) ?";CA
2024  INPUT "WHAT IS THE TOTAL NU
      MBER OF TEACHERS IN  THE SYS
      TEM ?";TNT
2025  INPUT "HOW MANY TEACHERS AR
      E IN THE SCHOOL ?";TIS
2026  INPUT "WHAT IS THE SCHOOL S
      ERVICE COST ?";SSC
2028  INPUT "WHAT IS THE AVERAGE
      TEACHER COST SALARY ";TCS
2030  INPUT "HOW MANY PERIODS DOE
      S THE TEACHER TEACH ";TP
2031  INPUT "HOW MANY STUDENTS AR
      E IN THE CLASS ?";SIC
2099  REM  DO SUMMARY WORK
```

```
2100  LET FF = (CA / TNT) + (SSC /
     TIS) + (TCS)
2110  LET CH = FF / (TP * 180)
2198  PRINT "HIT RETURN TO CONTIN
     UE": GET R$
2199  HOME
2200  PRINT "THE COST FOR THE PRO
     FESSIONAL SERVICES  IS EQUAL
      TO ";CH / SIC;" DOLLARS.": PRINT
     : PRINT
2201  PRINT "THIS, HOWEVER, IS NO
     T THE TOTAL COST TO  THE SYS
     TEM.  NON-PROFESSIONAL SERVI
     CES MUST BE INCLUDED."
2203  PRINT "HIT ANY KEY TO CONTI
     NUE.": GET KEY$
2205  HOME
2210  INPUT "WHAT ARE THE TRANSPO
     RTATION COSTS ?";TC
2212  INPUT "WHAT IS THE TOTAL NU
     MBER OF STUDENTS ?":TNS
2214  INPUT "WHAT ARE THE MAINTEN
     ANCE AND OPERATION  COSTS ?"
     ;MO
2216  INPUT "WHAT IS THE NUMBER O
     F STUDENTS IN THE  SCHOOL ?
     ";ST
2217  PRINT "IF THE INSTRUCTIONAL
      USE SPACE IS NOT   KNOWN TY
     PE (HELP) AND RETURN,OTHERWI
     SE ": PRINT "JUST HIT RETURN
      ": INPUT H$: IF H$ = "HELP"
      THEN  GOSUB 1000
2218  INPUT "WHAT IS THE PERCENT
     OF INSTRUCTIONAL USESPACE ?"
     ;IUS
2299  REM  SUMMARY STEPS
2300  LET S1 = (TC / TNS) / (6 *
     180)
2319  LET IU = IUS / 100
2320  LET S4 = ((MO / TNS) * (ST *
     IU))
2321  LET S5 = (S4) / (6 * 180 *
     SIC)
2340  LET S6 = S1 + S5
2399  HOME
2400  PRINT "THE NON-PROFESSIONAL
      COSTS ARE EQUAL TO ";S6;" D
     OLLARS.
2405  PRINT : INPUT "HIT ANY KEY
     TO SEE THE TOTAL COSTS.";KEY
     $
```

```
2410  HOME : PRINT : PRINT : PRINT
     : PRINT "THE TOTAL COSTS PER
      DAY ARE ";S6 + (CH / SIC);"
      DOLLARS."
2499  PRINT : PRINT : PRINT : PRINT
2500  PRINT "HIT RETURN TO CONTIN
     UE": GET R$
2999  GOTO 24: RETURN
3000  PRINT "THIS ROUTINE ASKS CE
     RTAIN QUESTIONS CON-CERNING
     ENERGY COSTS.  IT WILL BE NE
     CES-";: PRINT "SARY FOR YOU
     TO OBTAIN THE NEEDED INFOR-"
     ;
3001  PRINT "MATION FROM YOUR UTI
     LITY COMPANY(IES)   BEFORE P
     ROCEEDING."
3002  PRINT " PRINT "THE DATA IN
     THIS PROGRAM ARE FOR DUKE ":
      PRINT "POWER CO. AS OF 1 AU
     GUST 1982.  IF THE": PRINT "
     RATES CHANGE OR YOU ARE SERV
     ED BY SOME "
3003  PRINT "OTHER COMPANY YOU MU
     ST INSERT THE UP TO-";" PRINT
     "DATE DATA IN LINES 3700-390
     0.": PRINT : PRINT "THE RATE
     S ARE FOR NC ALL-ELECTRIC ":
      PRINT "SCHOOLS.": PRINT
3004  PRINT "DO YOU WISH TO UPDAT
     E ?"; GET A$: IF A$ = "Y" THEN
      GOTO 9999
3005  PRINT : FLASH : PRINT "HIT
     ANY KEY TO CONTINUE ": NORMAL
     : GET G$
3009  HOME
3010  PRINT : PRINT "WHAT WAS THE
      KWH CONSUMPTION FOR THE
     MONTH YOU WANT TO KNOW THE C
     OST ?": INPUT "ENTER THE KWH
     'S AND THEN HIT (RETURN)  ";
     KH
3700  REM  GA(NC) RATE
3705 LET B = 9.77
3707  PRINT "WHAT IS YOUR BILLING
      DEMAND IN KILOWATTS ": INPUT
     DC: IF DC > 30 THEN BD = 2.2
     3 * (DC - 30)
3708  IF DC < = 30 THEN DC = 0
3709  LET B1 = DC * 125:B2 = DC *
     400: IF KH - (B1 + B2) =  <
     0 THEN B2 = KH - B1
3710  B3 = KH - (B1 + B2): IF B3 <
     = 0 THEN B3 = 0
```

```
3712  IF B1 <  = KH THEN  GOSUB 3
      750
3713  IF B2 > 0 THEN  GOSUB 3761
3714  IF B3 > 0 THEN  GOSUB 3780
3720  PRINT "YOUR COST FOR THE MO
      NTH IS APPROXIMATELY";: INVERSE
      : PRINT "   $";(C3 + C6 + C9
      ) / 100 + ( INT (BD)) + B: NORMAL
      : PRINT
3725  PRINT : PRINT : PRINT "HIT
      RETURN TO CONTINUE": GET R$
3727  GOTO 24
3750  REM  DO FIRST BLOCK OF RATE
      S
3751  IF B1 =  > 3000 THEN BF = 3
      000
3752  IF BF = < 3000 THEN C1 = 6
      .7633 * BF
3753  IF B1 > 3000 AND B1 <  = 90
      000 THEN C2 = (B1 - 3000) *
      3.7217
3754  LET C2 = C2 + C1
3755  IF B1 > 90000 THEN C3 = 2.5
      205 * (B1 - 90000) + (87000 *
      3.7217)
3756  REM  ADD ALL NUMBERS FIRST
      BLOCK
3757  LET C3 = C3 + C2
3758  REM  ROUND OFF ALL ODD CENT
      S
3759 C3 =  INT (C3)
3760  RETURN
3761  REM  SECOND BLOCK
3763  IF B2 < 140000 THEN C4 = B2
      * 3.6054
3765  IF B2 = 140000 THEN C4 = 3.
      6054 * 140000
3767  IF B2 > 140000 AND B2 <  =
      200000 THEN C5 = (B2 - 14000
      0) * 3.3342 + (140000 * 3.60
      54)
3768  LET C5 = C5 + C4
3770  IF B2 > 200000 THEN C6 = 3.
      1498 * (B2 - 200000) + (1400
      00 * 3.6054) + (60000 * 3.33
      42)
3771  LET C6 = C6 + C5:C6 = INT
      (C6)
3772  RETURN
3780  REM  THIRD BLOCK
3781 KH = KH - (B1 + B2)
3784  IF KH = A 1000000 THEN C7 =
      KH * 3.1602
```

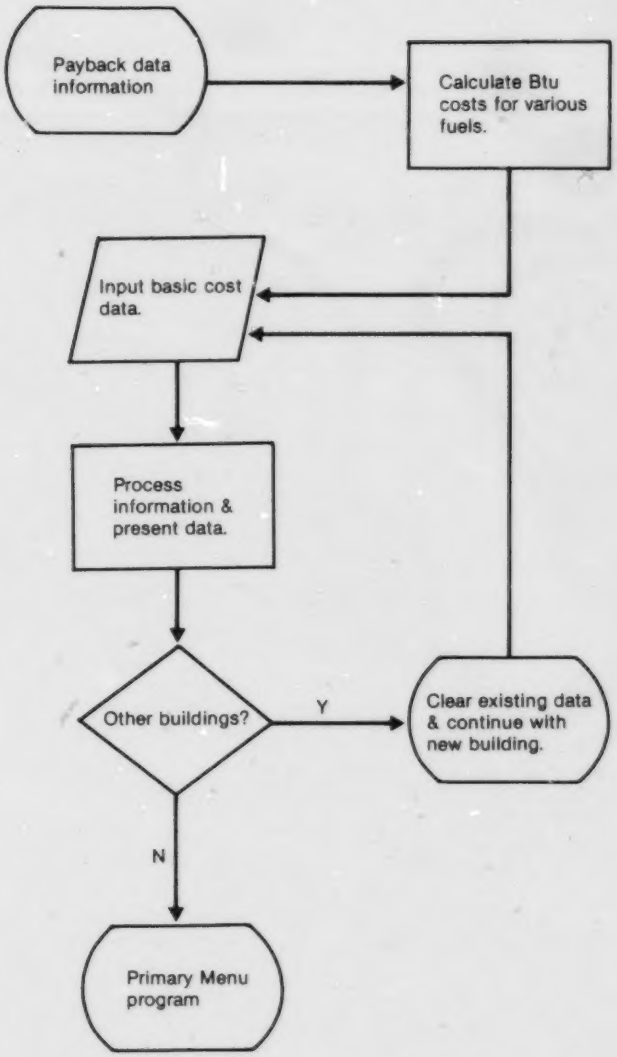
```
3785  IF KH > 1000000 THEN C8 = (
      KH - 1000000) * 3.0636
3786 C9 = C7 + C8:C9 = INT (C9)
3787  RETURN
4000  HOME : PRINT "THIS ROUTINE
      ALLOWS YOU TO DETERMINE HOW C
      LOSE YOU ARE COMING TO MEETI
      NG THE      ";: PRINT "NATIO
      NAL GOALS FOR ENERGY CONSUMP
      TION"
4005  PRINT "IN ORDER TO MAKE THE
      COMPARISONS IT WILL";: PRINT
      "BE NECESSARY FOR YOU TO KNO
      W YOUR ENERGY";: PRINT "USE
      IN KWH;CUBIC FEET;GALLONS; E
      TC."
4006  REM  CONVERSION FACTORS BAS
      ED ON STANDARDS FROM ASHRAE
4007  GOSUB 4040
4008  INVERSE : PRINT "HIT ANY KE
      Y TO CONTINUE": NORMAL : GET
      KEY$
4009  HOME : INPUT "TYPE THE NAME
       OF THE SCHOOL THEN HIT RE-T
      URN";SC$
4010  PRINT : PRINT "WHAT WAS YOU
      R TOTAL KWH USE ?  YOU MUST
      USE MONTHLY CONSUMPTION DATA
       IF THIS ";: PRINT "PROGRAM
      IS TO WORK PROPERLY!"
4012  PRINT : INPUT E
4020  INPUT "WHAT WAS YOUR CONSUM
      PTION OF NATURAL GAS IN HUNDR
      EDS OF CUBIC FEET (CCF/MONTH
      ) ?";NG
4025  INPUT "WHAT WAS YOUR CONSUM
      PTION OF OIL IN GAL-LONS ?";
      O
4027  INPUT "WHAT WAS YOUR CONSUM
      PTION OF COAL IN
      TONS ?";C
4028  INPUT "WHAT WAS YOUR CONSUM
      PTION OF LP GAS (IN GALLONS)
       ?";LP
4030  INPUT "ONE LAST BIT OF DATA
      NEEDED IS THE TOTAL SQUARE F
      OOTAGE OF THE BUILDING. ";SF

4035  GOSUB 4100
```

```
4040  PRINT : PRINT : PRINT "THE
     DATA THAT WILL BE PRESENTED
     WILL BE BASED ON INFORMATION
      FROM THE PIEDMONT ";: PRINT
     " CRESCENT ENERGY PROJECT AN
     D WILL HAVE   AN EFFICIENCY
     FACTOR INCLUDED.  "
4050  PRINT  TAB( 15)"ENERGY DATA
     "
4051  PRINT  TAB( 14)"==========
     =="
4052  PRINT
4053  PRINT "  ELECTRIC (KWH)....
     ...3.4"
4054  PRINT "  OIL #2 (GAL)......
     .138.69"
4055  PRINT "  NAT. GAS (CCF)....
     .103.0"
4056  PRINT "  COAL (TONS)......2
     4500.0"
4057  PRINT "  LP GAS (GAL)......
     ..95.475"
4059  RETURN
4099  REM  CONVERT ALL DATA TO BT
     U
4100  LET Z = E * 3.4
4110  LET Y = O * 138.69
4120  LET W = NG * 103
4130  LET V = C * 24500
4140  LET U = LP * 95.475
4150  LET TT = Z + Y + W + V + U
4155  LET TT =  INT (TT)
4160  PRINT : PRINT "YOUR MONTHLY
      BTU USE IS ";TT * 1000
4170 LET YT = TT * 1000
4180  PRINT : PRINT "THIS MAKES Y
     OUR YEARLY CONSUMPTION = ";Y
     T * 12;" BTU'S"
4189  LET YF = YT * 12
4190  PRINT : PRINT "ON A SQUARE
     FOOT BASIS YOU HAVE USED "; INT
     (YF / SF);" BTUS/SQUARE FOOT
     ."
4195  LET PC = YF / SF
4200  PRINT : PRINT "THE NATIONAL
      GOAL IS TO USE ONLY 55000
     BTU'S/SQ.FT."
4210  PRINT : PRINT "THIS MEANS T
     HAT YOU HAVE ACIEVED ABOUT "
     ; INT ((55000 / PC) * 100);"
     % OF THE NATIONAL GOAL."
```

```
4500  PRINT : PRINT : PRINT : PRINT
     "DO YOU HAVE OTHER ENERGY CO
     STS (Y/N) ?": GET Q$: IF Q$ =
     "Y" THEN  GOTO 4009
4999  GOTO 24
9999  HOME : VTAB (10)
10000  PRINT "YOU MUST TYPE -LIST
      3700,3900.  THIS ": PRINT "
     WILL LIST THE PROGRAM LINES
     CONTAINING "
10005  PRINT "THE MATHEMATICS OF
     THE RATE SCHEDULE.": PRINT "
     SIMPLY CHANGE THE RATES AS N
     EEDED."
10010  PRINT "AFTER THE CHANGES H
     AVE BEEN MADE TYPE ": PRINT
     "RUN AND THEN HIT THE (RETUR
     N KEY)."
10020  END
63000  REM  PROGRAM CREATED FOR I
     NTERNSHIP ED.350
63001  REM  AT DUKE UNIVERSITY, D
     URHAM, NC
63514  REM  FOR DR. ROBERT PITTIL
     LO OF THE DEPT. OF EDUCATION

63599  REM  COPYRIGHT BY STEPHEN
     CANIPE
63600  REM  BY STEPHEN CANIPE,230
     1 E. PROVIDENCE DR.,MATTHEWS
     ,NC 28105 (704)847-0280
63999  END
```

Figure 72

Payback Program



This flow diagram indicates the directions in which the user may proceed from various points in the Payback program.

Payback Program Listing

```
0     TEXT
10    HOME
15    REM  PAYBACK /LIFE CYCLE COST
       ING PROGRAM
20    PRINT "THIS PROGRAM IS THE KE
       Y ONE FOR ": PRINT "DETERMIN
       ING THE NET EFFECT OF ANY "
21    PRINT "ADDITIONS TO YOUR BUIL
       DINGS.": PRINT "IN ORDER TO
       USE THIS PROGRAM WITH THE "
22    PRINT "GREATEST BENEFIT IT WI
       LL BE NECESSARY ": PRINT "TH
       AT YOU HAVE COMPLETED THE OT
       HER PARTS"
23    PRINT "OF THE PACKAGE AND HAV
       E THE COMPLETED": PRINT "DAT
       A SHEETS BEFORE YOU."
24    PRINT "THIS PROGRAM WILL ANAL
       YSE THE CURRENT": PRINT "SAV
       INGS, LOOK AT LONG TERM SAVI
       NGS AND": PRINT "FIGURE PAYB
       ACK TIME."
25    PRINT "THIS WILL BE DONE IN A
        GENERAL MANNER ": PRINT "AN
       D BE APPLICABLE TO ANY ENERG
       Y SOURCE."
30    VTAB (15)
31    INVERSE : PRINT  TAB(38);" "
       : PRINT
32    PRINT "HIT ANY KEY TO CONTINU
       E"
33    NORMAL
35    GET A$
36    GOSUB 2000
50    REM  DEBT SERVICE CONSTANT
55    HOME : VTAB (5)
100    INPUT "WHAT IS YOUR INTEREST
        RATE ?";I
105    IF I > 1 OR I < 0 THEN  PRINT
       "LIST INTEREST IN DECIMAL FO
       RM (.04).": GOTO 100
106    IF I = 1 THEN  PRINT "ONE CA
       NNOT PAY 100% INTEREST."
107    IF I = 1 THEN  GOTO 100
110    PRINT "WHAT IS THE USEFUL LI
       FE OF THE ADDITION": PRINT "
       WE SHALL ASSUME FINANCING FO
       R THE ": PRINT "DURATION.": INPUT
       LN
115    LET A = (1 + I) ^ LN
120    LET B = A * I
```

```
125   LET C - (1 + I) ^ LN
130   LET D = C - 1
135   LET E = B / D
141   PRINT "YOUR DEBT SERVICE CON
      STANT IS ";E"."
200   REM  AMORTIZATION COST FOR C
      APITAL INVESTMENT
210   INPUT "WHAT IS THE DIFFERENC
      E IN CAPITAL COSTS OF THE TW
      O STRUCTURES ? (DOLLARS)";F
215   LET H = E * F
220   PRINT "YOUR AMORTIZATION COS
      T FOR THE ADDED"
221   PRINT "INVESTMENT IS $ "; INT
      (H)
300   REM  BENEFIT COST RATIO
305   INPUT "WHAT IS THE YEARLY O&
      M COST FOR SYSTEM  A?";SA
306   INPUT "WHAT IS THE YEARLY )&
      M COST FOR SYSTEM B?";SB
307   LET G = SA - SB
310   PRINT "THE ANNUAL OPERATION
      AND MAINTENANCE ": PRINT "SA
      VING IS $ ";G
315   LET CBR = G / H
316   LET CBR =  INT (CBR * 1000):
       LET CBR = CBR / 1000
320   PRINT "YOUR COST BENEFIT RAT
      IO IS ";CBR
340   IF CBR < 1 THEN GOTO 10000
500   REM  TIME TO RECOUP INVESTME
      NT
501   PRINT "FOR THIS EXAMPLE IT I
      S ASSUMED THAT THE ENTIRE O&
      M SAVING WILL BE USED TO PAY
         OFF THE LOAN."
505   REM  DO PAYBACK MATH
510   LET J = G / (I * F)
520   LET K = J - 1
530   LET L =  LOG (J / K)
540   LET M =  LOG (1 + I)
545   LET N = L / M
546   LET N = INT (N * 100): LET
      N = N / 100
550   PRINT "THE NUMBER OF YEARS T
      O PAY BACK THE LOAN IS ";N
560   REM  TOTAL LONG TERM SAVING
570   PRINT : PRINT : PRINT : PRINT
      : PRINT "IN FIGURING THE TOT
      AL LONGTERM SAVINGS"
575   PRINT " IT IS NECESSARY TO C
      ONSIDER ANNUAL O&M AS WELL A
      S ADDITIONAL AMORTIZATION CO
      ST."
```

```
580   PRINT "FOR YOUR BUILDINGS TH
      IS AMOUNTS TO $ "; INT (SB +
      H)
585   LET DS = G - H
586   LET OA = I + 1: LET OB = OA ^
      LN
590   LET O = OB - 1
595   LET P = I * OB
600   LET PW = DS * (O / P)
601   LET PW =  INT (PW)
605   PRINT "THE PRESENT WORTH OF
      THE "LN;"-YEAR DIF-": PRINT
      "FERENCE IS $ ";PW
700   REM  COST-SAVINGS WITH RISIN
      G FUEL COSTS
705   PRINT "FOR THIS PART OF THE
      PROGRAM IT IS NECESSARY TO K
      NOW ANNUAL FUEL COSTS FOR TH
      E  TWO BUILDINGS."
710   INPUT "WHAT IS THE ANNUAL FU
      EL COST FOR NUMBER ONE?";FA
715   INPUT "WHAT IS THE COST FOR
      BUILDING TWO?";FB
720   PRINT "AN AVERAGE COST INCRE
      ASE OF 7% IS USED  FOR FUEL
      COST."
730   LET G = .07
735   LET AA = 1 + G: LET AB = 1 +
      I: LET AC = AA / AB
740   LET AD = (AC ^ LN): LET AE =
      AD - 1
745   LET AF = AC * AE: LET AG = A
      C - 1: LET AH = AF /AG
750   LET EC = FA * AH
755   LET BC = FB * AH
758   LET EC = INT (EC): LET BC =
       INT (BC)
760   PRINT "ENERGY COSTS FOR BUIL
      DING ONE ARE $ ";EC;"FOR THE
       ";LN;"YEARS."
765   PRINT "ENERGY COSTS FOR BUIL
      DING TWO ARE $ ";BC;"FOR THE
       SAME PERIOD."
770   PRINT "THIS RESULTS IN AN EN
      ERGY SAVINGS OF $ ";EC - BC;
      "."
775   LET BA = O / P
780   PRINT "THE LIFETIME MAINTENA
      NCE COSTS FOR ": PRINT "BUIL
      DING ONE ARE $ "; INT (SA -
      FA) * BA)
781   LET MA = (SA - FA) * BA
785   LET TA = (SB - FB) * BA
```

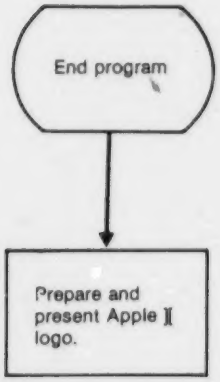
```
786   LET MA =  INT (MA): LET TA =
       INT (TA)
790   PRINT "THE LIFETIME COSTS FO
      R BUILDING TWO ARE $ ";TA
800   PRINT "THIS RESULTS IN A MAI
      NTENANCE SAVINGS OF $ ";MA -
      TA
805   LET MT = MA - TA
810   PRINT "IN SUMMARY THE SAVING
      S AND COSTS WHICH CAN BE AT
      TRIBUTED TO THE MORE EFFICIE
      NT STRUCTURE ARE:"
815   PRINT : HTAB (10): PRINT "EN
      ERGY SAVINGS......$ ";EC - B
      C
816   LET ET = EC - BC
820   PRINT : HTAB (10): PRINT "MA
      INTENANCE SAVINGS.$ ";MT
825   PRINT : HTAB (10): PRINT "OR
      IGINAL COST.......($ ";F;")"

830   PRINT "WHAT THIS AMOUNTS TO
      IS A 'PRESENT      WORTH' SA
      VINGS  FOR THE ";LN;"-YEAR P
      AYBACK OF THE LOAN OF $ ";(E
      T + MT) - F
831   PRINT "FOR BUILDING TWO...TH
      E MORE ENERGY      EFFICIENT
       STRUCTURE."
1000  PRINT : PRINT : INVERSE : INPUT
     "DO YOU HAVE OTHER BUILDINGS
      YOU WISH TO COMPARE ?(Y/N)"
     ;Q$
1005  NORMAL
1010  IF Q$ = "Y" THEN  GOTO 10
1015  REM  CNTRL-D IN QUOTES
1020  PRINT "RUN PRIMARY MENU"
2000  REM  CHECK BTU COST PER UNI
     T
2001  HOME : PRINT "IN ORDER TO F
     IGURE COSTS PROPERLY IT ": PRINT
     "WILL BE NECESSARY TO GET SO
     ME DATA "
2005  PRINT "CONCERNING YOUR FUEL
      COSTS.": PRINT "IF YOU HAVE
      MORE THAN ONE TYPE OF FUEL
     "
2007  PRINT "IT WILL BE NECESSARY
      TO FIGURE EACH.  ": PRINT "
     RESPOND TO THE QUESTIONS AND
      THE PRO-": PRINT "GRAM WILL
     DO THE REST."
```

```
2008  PRINT "IN THE EVENT THAT YO
      U DO NOT HAVE THE ": PRINT "
      SOURCE LISTED HIT '0' AND (R
      ETURN)."
2009  PRINT : PRINT : PRINT "WHAT
       IS YOUR COST PER KILOWATT-H
      OUR FOR": INPUT "ELECTRICITY
       ?";EC
2010  IF EC > 1 THEN  PRINT "LIST
       IN DECIMAL FORM (.05)": GOTO
      2009
2012  PRINT "WHAT IS THE COST PER
       HUNDRED CUBIC FEET ": INPUT
      "OF NATURAL GAS ?";NG
2015  PRINT "WHAT IS THE COST PER
       GALLON OF OIL ?": INPUT OL
2020  INPUT "WHAT IS THE COST PER
       TON FOR COAL ?";CO
2025  INPUT "WHAT IS THE COST PER
       GALLON FOR LP GAS ?";LP
2030  SPEED= 100: PRINT "     ":
      SPEED= 255: REM  CONTRL-G IN QUOTES
2048  REM  GET COST PER BTU
2050  LET ECC = EC / 3412
2055  LET NGC = NG / 103000
2066  LET OLC = OL / 138690
2070  LET COC = CO / 2450000
2075  LET LPC = LP / 95475
2078  REM  FIGURE TOTAL COST SAVI
      NGS
2080  PRINT "HOW MANY BTU OF ELEC
      TRICITY ARE SAVED?": INPUT B
      EC: LET EC = BEC * ECC
2085  PRINT "HOW MANY BTU OF NATU
      RAL GAS ARE SAVED?": INPUT B
      NG: LET NG = BNG * NGC
2090  PRINT "HOW MANY BTU OF OIL
      ARE SAVED ?": INPUT BOL: LET
      OL = BOL * OLC
2095  PRINT "HOW MANY BTU OF COAL
       ARE SAVED?": INPUT BCO: LET
      BCO = BCO * COC
2100  PRINT "HOW MANY BTU OF LP G
      AS ARE SAVED ?": INPUT BLP: LET
      LP = BLP * LPC
2103  REM  TO ROUND TO EVEN DOLLA
      RS
2105 EC =  INT (EC):NG =  INT (NG
      ):OL =  INT (OL):CO =  INT (
      CO):LP =  INT (LP)
2107  LET TLT = EC + NG + OL + CO
       + LP
```

```
2110  PRINT "YOUR TOTAL SAVINGS A
     RE $ ";TLT
2199  REM  RETURN TO MAIN PROGRAM

3200  PRINT "HIT ANY KEY TO CONTI
     NUE  ": GET A$: RETURN
10000  HOME : INVERSE " FOR I = 1
      TO 24: PRINT "PAYBACK TIME
     TOO LONG FOR THIS ANALYSIS "
     : NEXT I
10010  NORMAL : GOTO 1000
63000  REM  COPYRIGHT- STEPHEN CA
     NIPE 1982 MATTHEWS  NC 28105
```

Figure 73

End Program



This flow chart shows the simplicity of the End program. The only way to return to any of the subprograms is via restarting the title program.

End Program Listing

```
0    REM   THIS PROGRAM WILL DRAW A
       N APPLE AND PRINT APPLE II
1    TEXT : CALL  - 936: GR
9    REM   PRINT GREEN STEM AND TOP
       BAND
10   COLOR= 12: PLOT 11,2: VLIN 3,
      4 AT 10: PLOT 9,5: HLIN 3,8 AT
      6: HLIN 10,15 AT 6: HLIN 2,8
      AT 7: HLIN 10,16 AT 7: HLIN
      1,17 AT 8
19   REM  PRINT YELLOW BAND
20   COLOR= 13: HLIN 1,17 AT 9: HLIN
      1,17 AT 10: HLIN 0,17 AT 11:
      HLIN 0,16 AT 12: HLIN 0,15 AT
      13
29   REM   DRAW ORANGE BAND
30   COLOR= 9: HLIN 0,15 AT 14: HLIN
      0,14 AT 15: HLIN 0,14 AT 16:
      HLIN 0,14 AT 17: HLIN 0,14 AT
      18: HLIN 0,14 AT 19
39   REM   DRAW RED BAND
40   COLOR= 1: HLIN 0,14 AT 20: HLIN
      0,15 AT 21: HLIN 0,15 AT 22:
      HLIN 0,16 AT 23: HLIN 0,17 AT
      24: HLIN 0,19 AT 25
49   REM   DRAW VIOLET BAND
50   COLOR= 3: HLIN 0,18 AT 26: HLIN
      1,17 AT 27: HLIN 1,17 AT 28:
      HLIN 1,17 AT 29: HLIN 1,17 AT
      30: HLIN 2,16 AT 31
59   REM   DRAW BLUE BAND
60   COLOR= 2: HLIN 2,16 AT 32: HLIN
      2,16 AT 33: HLIN 3,15 AT 34:
      HLIN 3,15 AT 35: HLIN 4,8 AT
      36: HLIN 10,14 AT 36
69   REM   CHANGE TO WHITE LETTERS
       FOR APPLE II :REM -A-
70   COLOR= 15: HLIN 17,19 AT 17: HLIN
      17,19 AT 19: HLIN 17,19 AT 2
      1: VLIN 17,21 AT 19: PLOT 17
      ,20
79   REM   -P-
80   VLIN 17,25 AT 21: VLIN 17,21 AT
      23: PLOT 22,17: PLOT 22,21
89   REM   -P-
90   VLIN 17,25 AT 25: VLIN 17,21 AT
      27: PLOT 26,17: PLOT 26,21
99   REM   -L-
100   VLIN 13,21 AT 29
109   REM   -E-
```

```
110   VLIN 17,21 AT 31: HLIN 31,33
       AT 17: HLIN 31,33 AT 19: HLIN
      31,33 AT 21: PLOT 33,18
119   REM  -II-
120   PLOT 35,13: PLOT 39,13: PLOT
      35,21: PLOT 39,21: VLIN 13,2
      1 AT 36: VLIN 13,21 AT 38
130   REM   WRITTEN BY STEVE CANIP
      E,2301 E. PROVIDENCE DR,MATT
      HEWS,NC 28105 12/24/80
140   PRINT "           THANKS FOR
      USING THIS PROGRAM"
141   PRINT "         ============
      ================"
999   END
63000   REM  COPYRIGHT-STEPHEN CAN
      IPE-1982 MATTHEWS NC 28105
```

VARIABLES LIST

PRACTICAL ENERGY MODEL

1. C=Tons of Coal
2. CA=Central Administration
3. CBR=Cost Benefit Ratio
4. DC=Demand Charge in Kilowatts
5. E=Average Number of Kilowatt-hours
6. F=Difference in Capital Cost
7. FA=Annual Fuel Costs for System A
8. FB=Annual Fuel Costs for System B
9. I=Interest Rate
10. IP=Instructional Space Area
11. IU=Percentage of Instructional Use Space
12. IUS=Instructions use space area
13. KH=Kilowatt-hours
14. LN=Number of years of the loan
15. LP=Gallons of LP Gas
16. MO=Maintenance Costs
17. NG=CCP of Natural Gas
18. O=Gallons of Oil
19. SA=O & M for System A
20. SB=O & M for System B
21. SF=Square Feet
22. SIC=Number of Students in class
23. SSC-School Service Cost
24. ST=Number of Students in school
25. TC=Transportation Costs
26. TCS=Teacher Cost Salary
27. TIS=Number Teachers in school
28. TNT=Total Teachers in System
29. TP=Teaching Periods of Teachers

Fig. 74. Figure showing the variables used in the SRDAS

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BIOGRAPHY

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The author was born in Lincolnton, North Carolina on 9 January 1946. He is married and has one daughter.

He attended the Lincoln County public schools and was graduated from West Lincoln High School in 1964. From high schol he enrolled at Appalachian State University in Boone, North Carolina where be majored in biology.

After graduation from Appalachian, he began teaching high school biology in the Charlotte-Mecklenburg School System. In the course of his employment with the Charlotte-Mecklenburg Schools, he was appointed project coordinator for a federally funded environmental education project. The author was the editor of the book that was published as a result of the project entitled Valuing the Environment. He also worked as an assistant principal in a junior high school in Charlotte.

During his employment with the school system, he was offerred a National Science Foundation fellowship to pursue an advanced degree. He accepted the grant and was graduated from Michigan State University in East Lansing, Michigan with a master of science degree in environmental science. His master's thesis was entitled A Limnological Survey of a Small Pond.

After eight years with the Charlotte-Mecklenburg Schools, he accepted a position with the North Carolina Department of Public Instruction as Energy Consultant in the Science Division. He remained in this position for one year and then accepted a position with Duke Power Company as Supervisor of Educational Services in the company's headquarters in Charlotte. His

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The author is a member of many professional and academic organizations. Among these organizations are Kappa Delta Pi, Phi Delta Kappa, International Association of Business Communicators, Association for Supervision and Curriculum Development, and National Association for Industry-Education Cooperation. He is listed in Who's Who in the South and Southwest and in Outstanding People of the South.

The author was awarded a doctoral degree in the area of educational administration at Duke University. His dissertation concerns the use of a microcomputer in conducting school building energy audits.